

NASA Administrator
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It's really a privilege to be here. I spoke at the gathering last year in Atlanta, Georgia. I talked about the ^{obligation of the scientific community} author's task of communicating ^{to communicate directly and clearly with the American public.} numerically. The criticality of the scientific community not looking into itself would recognize that the American public is picking up the bill for all the science that we do, and sometimes in the joy and passing what we forget that the ultimate consumer of science and technology that we're working on for the American public.

And a hell of a story about the American public. And this story takes place in November of last year. My wife and I had just moved into a house up on Capitol Hill and I was trying to get the phones hooked up. I got the phone line hooked up but I couldn't get the fax line hooked up and I was feeling kind of naked at the time without my fax at home. So we arranged for a technician from Bell Atlantic to show up at our house at 9 o'clock on Thursday morning, which was I think, the week before Thanksgiving. And it was clear why I would be there 9 o'clock, was I was non-essential and the Government had shut down. So my wife went off to work and made sure I took care of all the chores in the house.

It was also an interesting day because at 11:10 that day I was going to communicate with the International Crew on Board the MIR, from my house. And I had refused to go into NASA Headquarters because we were on furlough and I felt it inappropriate that the Administrator bring in the crew in the TV studio so I could talk to them, so I just asked Mission Control, can I make this call from my house? And they said, sure.

So 9 o'clock passes, 9:30, 10 o'clock, 10:30. A few minutes to 11 the doorbell rings and there's this big, tall guy at the door and he can hardly speak English and he says, hi, I'm from Bell Atlantic. I'm here to put in your fax line. I said I know, but I've got something important to do. So he says, "I can handle it real quick, don't worry." So I opened the door, he goes dashing into the room, he says, where's the plug for the fax line? And in our kitchen we have two plugs, one for the phone line which was alive, and one for the fax line which was dead. So he immediately injects his tool into the fax line and Mission Control's calling me and they hear, whoo,

whoo, whoo. So I said, could you pull it out, please? He says, "not to worry. You've got a few minutes before the phone call." I said this is a very important call.

So finally he pulls it out. It's now five or six minutes after 11 and Laurie Boeder who is the head of Public Affairs, came to my house so she could be there just to see what was going on. And by this point in time the tears are just falling down her cheeks, it's so funny. And I didn't want to tell him because I felt he wouldn't believe it. So, he says, I'll tell you what. If you don't want me to work in the house I'll go to the switchboard outside, and I said, please don't. So it's now 9 minutes after 11, we're all getting kind of nervous, so I said, here look, why don't you sit on this couch next to Laurie? And I turned on the TV and there are the astronauts floating around, and all the different flags, and he still doesn't get it.

So I said, I'm going to talk to space. He rolls his eyes. (laughter) And then he hears my voice coming through the TV. The guy about died. (laughter) And it was really an historic event because we sent the shuttle up to a Russian space station, we had a Russian on board, a German on board, we had a Canadian on board, and the Americans. I mean, this was almost a representation of all the people aboard the space station. The only people that weren't represented were Japan. I mean, it was really an historic mission.

And I was still all wrapped up in the mission. I didn't appreciate this until, you know, I thought about it afterwards. And then he listened to it and I mean, this man was glued to the TV. And when it ended I said, what did you think of it? And he said, you know what? Space is about my children's future. Those were the only words that he could get out of his mouth. And here's someone who's relatively uneducated, new to this country, but he understood the criticality of space in the future of his children. The connection was right there. And sometimes when you're inside the beltway and you listen to the cynicism that comes out, you don't appreciate that America wants to open the space frontier. People on this planet want to open the space frontier, and they're sick and tired of bureaucracy getting in the way.

And after that experience, all of a sudden there was an unbelievable sizzle that took place. Galileo got to Jupiter. I mean, if you think about the probability of that happening- the Perils of Pauline- and then the miracle of the incredible brains of the people that designed that mission, it's breathtaking. You know, the margin for error, assuming everything worked, was so unbelievably low, that you ask yourself, how did it happen? And then shortly thereafter, I turned on the TV and there's an

excited newscaster showing a picture of deep field galaxy. And as excited as could be, as excited as anything happening in, you know, Bosnia, in Haiti, over the budget.

And then I had the opportunity to talk before the American Astronomical Society a few weeks ago in San Antonio. And I was going to talk about origins, and even though we're talking about humans in space I'm going to talk about the origins program today and put it in context. And before I give a talk I like to, if I have an opportunity, talk to some scientists involved, so I had dinner with a number of scientists. Geoff Marcy was there and Alan Dressler -- a whole bunch of people. And I was all excited about talking about subjects, and halfway through the conversation Geoff Marcy says to me, "Do you know what I'm going to talk about tomorrow?" And I said, no. And he whipped out this data showing he had found two planets circling stars within 35 light years of Earth.

I mean. I couldn't believe what I was looking at. And these planets were in the quasi-life zone. And I'll talk about it that; I want to define that a little later. So, if you think about it, if we can pick a time in history, all of history, you say, when do I want to be alive and when do I want to be there? It's in 1996 and '97. I don't know if you realize what's about to happen. We are finally getting a chance to open the space frontier. Now, there's some things we've got to fix, but you know, you talk to some of these people, they say hey, wait till you see what I'm going to show you next.

This is unbelievable. It's the type of thing that they want to put on Nightline. So instead of worrying about the budget, why we can't work as Democrats and Republicans, as Americans together, here is something that's definitely superior to this whole thing. But we're not stopping. We have resources up there, we have resources on the ground. Next week we're launching the NEAR spacecraft. We started on it three years ago. We didn't debate it. We just started the program and we're building it, we're launching it on the 15 February, and it's going out to an asteroid, and it's going to orbit 20 miles above that asteroid and we're going to learn almost everything we wanted to learn. I know Gene Shoemaker still needs some more data, and I'm sure we'll find some more missions for Gene.

And then this summer we're going to launch the Mars Global Surveyor and the Mars Pathfinder. Three years. Half the price of one Mars Observer, which disappeared. Every time I go back to California they say, have you found Mars Observer yet? We'll launch Lunar Prospector in '98. We want to see if there's water at the South Pole. That might be the most valuable water anywhere in the solar system. Cassini is being launched earlier than

we initially projected. Close to a billion dollars less money. That's why we launched in October '97. No launch start (inaudible) Cassini is going to go to Saturn (inaudible).

We just started a program, I think a month ago. It's called Stardust. We're going to go out and collect dust from comets and then separately collect intergalactic dust. And then the samples are coming back to earth. We're going to launch that spacecraft in three years. We just started it. What if we find some building-block of life in those samples. What else might we find?

And then in the summer of '98 we're going to launch Deep Space One. I made up the name. (laughter) I didn't know what else to call it. Kind of feels good. We are going to, for the first time after 30 years of development, utilize electric propulsion. Absolutely crucial for the exploration of space. Real advanced sensors are going to rendezvous with a whole bunch of small bodies. And then Mars. In '98, launch a global surveyor, Mars Lander II. And maybe even Mars Penetrator I. Then we get to 2000 Deep Space II. This is going to be the first experiment in interferometric techniques in space based upon work we're doing with Keck and on the Mount Palomar interferometer.

We thought the problem was going to be the beam forming networks and the metrology, knowing where things are to within a pico-meter, and having pointing accuracies of a fraction of a micro-arcsecond. That's not the problem. I will talk about what the rest of the problem is later. But these are on the books, and we've put them on the books even though the NASA budget's coming down. Someone there in the press conference said, "NASA's coming apart." I don't understand. I just don't understand, because people in the past measured the vitality of NASA by the dollars going in, by how big an organization they had, by how much paperwork they had, and how to satisfy the bureaucrats in Washington, how much punishment could they inflict on the nation?

I'm proud to say our budget has come down. We started 25 new programs with 20,000 less people in this great government. And there's going to be another 35,000 less. And I feel on a human basis, that this is a vital and alive program. Hubble is going to be up there, and next year, just about a year from today, we're going to put in a UV spectrometer, and we're going to put in a NEAR-IR imaging spectrometer. Think about what's going to come out of Hubble. And it's not going to be done without people. They're going to be astronauts who do it, and I'm proud to say there are going to be astronauts. And we're working with the KECK Foundation: we're helping build KECK-II and this May we're going to dedicate it and we're going to

start getting first light in October of this year.

And then with the data from the Mount Palomar interferometer we're going to update the beam forming at the KECK Observatory in Hawaii. And when they get the interferometric measurements we'll begin to get some sense about extra solar zodiacal light, and hopefully we'll detect- directly from the ground- a whole bunch of Jupiter-class planets. And again we'll move forward. And then we're going to study the earth's environment. We're going launch the Lewis Spacecraft, the Clark Spacecraft, the TRMM Spacecraft, Topex follow-on.

I noticed our French friends here. EOS AM-I, EOS PM, Landsat, Sea Star. These are all going to happen, and starting in '99, every year we're going to launch a new earth science probe. So it's amazing that for less money things are happening. We intend to open the space frontier, not to provide jobs for people in the industry. Not to provide jobs for bureaucrats and not to provides jobs for bureaucrats in universities. Perish the thought. They're there too, 'cause they're not just in the government. We want people to work with us who want to open up the space frontier. This is not just intellectual. It touches the human spirit.

I took with me two issues of Time magazine I mean, I read lots of publications. I could take bunches of them. But look, here's Time Magazine. The cover of Time Magazine. Not about death and killing. It says, 'Is anybody out there? How the discovery of two planets brings us closer to solving the most profound mystery in the cosmos'. This says there's more to life than survival- that as human beings we need intellectual nourishment as much as we need food, as much as we need shelter. And it's built-in to our culture. And even more stunning, this is another Time magazine I don't have my reading glasses on, but I think it's from December of '95. It says, 'Evolution's Big Bang'. If you haven't read about it in either this or any of the scientific journals, there's been some new findings that in a 10-million-year period, about a half-billion years ago, it seems everything happened. We went from single-cell organisms to the most complex structures. And if we have a sample of one planet earth, I'm not sure we'll sure we'll ever be able to answer why. And for that reason alone, and I'll talk about many others, we need to explore.

So we shouldn't worry about just the day-to-day things because they'll get taken care of, believe me. We have 535 people in Washington worrying about the day-to-day activities. What we have to do as scientists and engineers is think beyond the next fiscal year, beyond the next quarter. We have to think 20 or 30 years out, so that Bell Atlantic technician is assured that his child will have a real future. This is what drives me. I

mean, every day I have to pinch myself and say, oh God, look at the job you've got. What a privilege that the President of the United States lets you come into work each day. And each day I say, whew, I made it through another day. He may decide not to. And that's been known to happen.

So what we have to do is have some unifying vision, and that vision isn't, let's run straight for the planet we could go to. We have to think about asking some fundamental questions and seeing how we tie science and commerce together. And commerce is not a dirty word at NASA, because science, technology and commerce are absolutely integrally aligned. And some of the feedback the American public gets from the space program is the improvement in the quality of life giving them the technologies we undertake. But the real payback is going to be when we open the space frontier and make it part of our economic system. And that will be as far away as we allow them.

[So I'm here today to pose questions, tie issues together, to explore issues, set goals, and talk about how we're setting some thresholds. What I will not do today is announce a disconnected feel good mission. And I remember on the 25th anniversary of the celebration of Apollo, there was an unbelievable pressure. "Hey Dan, is NASA or the President going to announce we're going to Mars?" Absolutely not. That would have been the wrong thing. Because then we'll be back to where we were. We had this organic shuttle program. Now, I don't want to be demeaning to the people that worked on the shuttle, but the shuttle has suppressed a lot of science that we could be doing. There's no reason we shouldn't have been doing these things 10, 20 years ago. So we have to fight the temptation of getting an organic feel-good program that could destroy the integration of what we're trying to do.]

Before I talk about this, I'd like to thank a number of people I consulted with. Harry Holloway, Wes Huntress, Sam Venneri, Jeff Plescia, Diane Ballard. I talked to Gene Shoemaker at the Galileo encounter, France Cordova, Carl Pilcher, Mike Myer and Dr. Townes. I picked everybody's brain, and I tried to synthesize some of the thoughts that people have, because no one person has all the wisdom.

What I tried to do here is list what I consider to be three fundamental, interconnected questions that we have to answer. They're multi-disciplinary questions. It's not about a spectrum or a mission, it's about answering the fundamental questions, because the American public doesn't know what a Cassini is, but they know what fundamental questions are.

First, where do galaxies, stars and planetary bodies come from? How do they evolve? Two, are there other places that had an environment and in the broader sense of the word, have an environment or might have an environment hospitable to life and/or commerce? Three, is life of any form unique to planet earth? And I think this is what... this is the fine line I was trying to get at... and, that I think, is what turns people on. So stet is not a program I'll talk about today, not a discipline, not an agency, not a specific date, but an integrated, multi-disciplinary, technological, cultural and economic quest.

We are interested in sustained presence in the solar system. We are not interested in rushing off to Mars, spending tens of billions or hundreds of billions of dollars and stopping the scientific pursuit so a few people can feel good and a couple of companies will get big contracts. That's not what we're going to do.

Now, to attempt to answer these questions, we could perform the following task. And again, I think this has be decided by the people in this room, scientists and engineers around the world, and I'm only proposing these as a starting point and I hope they'll stimulate discussion. First, survey space to search for and analyze the earliest forms of galaxies. Two, search for and analyze stars and planetary systems in the process of forming. Three, search for and analyze extra-solar planetary systems in our neighborhood. And our neighborhood is defined as, as far as the aided eye can see. And right now it can't see very far. It's blurry. We now are myopic. Four, to search for and analyze planetary bodies that were, are or could be, habitable and/or could have resources of economic interest.

Five, Search for resources and/or signs of life including alternate life forms that we don't even know about. We just found some alternate life forms at the bottom of the ocean that don't operate the way other life forms operate, and if we can have it on our planet, by God, we could have it on others in our own solar system which we have yet to go to and appropriately explore. Six, attempt to determine some of the factors controlling the origin and fate of the universe and our solar system. Everyone wants to know.

And it brings to mind a story. I went to my daughters' school when they were in elementary school, and I talked about the solar system, the sun, planets and relative planet positions, and then I made the mistake of telling these 9-year-old children, that the sun's going to burn out in five billion years. They got hysterical. (laughter) But these children were giving an honest emotion. Think about our own feelings as adults. So these are not insignificant questions.

And finally, and most importantly, to benefit people in America and on the planet from the richness of the findings and technologies. And you can't do this with a single point program like Apollo. You can't do this with a Sprint; it's a marathon and demands revolutionary change, not evolutionary change. Let me give you an example.

The Hubble Space Telescope. I love it. Six billion dollar life cycle. Unconscionable. It weighs 25,000 pounds. It costs us a quarter of a billion dollars a year. It's getting great results, but at what cost? And we have to get into more of a cost/benefit analysis. So I challenge you and I'll talk about it later to the people in this room and people across the nation- I'll talk about how I think you can get there, without being specific. We need more than an order of magnitude reduction in weight. We need at least a factor of 20 reduction in cost. And we need at least a factor of two decrease in the size of that telescope. And that technology needs to be developed in the next ten years. We could do it.

People out on the west coast... in fact, I saw Roger Angel here. Roger tells me he can do it. He's a little too heavy, but he can get it down a little bit. So everything is connected, and new relationships between industry and academia and government and the American people have to take place. The Apollo era is gone. America spent five percent of its budget to go to the moon because we had to beat the Russians, and that was the right answer. Our budget is now nine-tenths of one percent. So I will fight anyone who wants to rush forward for a feel-good mission to the moon, that doesn't have revolutionary technology. Not for the technology sake, but we need orders of magnitude of reduction in cost, so we get the cost/benefit ratio -- so industry could begin to think about getting involved. So 20th Century thinking is out, and 21st Century thinking is in.

Now, if you take a look at NASA, a silent revolution happened. I think we could go, and I don't think anyone would notice it. NASA is no longer an object-oriented program. We no longer have a Space Physics Division to serve the space physics people in the university system. We no longer have a Planetary Division that has a community that needs so many hundred million dollars a year. We no longer have an Astro-physics Division. We have intellectual leadership at headquarters based upon questions that need to be answered, and multiple disciplines. We no longer organize ourselves around wavelengths. We no longer feel constituent-oriented, the people who go to the Congress and have to have a specific level of budget so that they don't have to lay people off.

Now, I don't want to appear heartless. We've got to be dominated by work

that's outstanding, and the work cannot be subsidized by the American people to provide stability in laboratories. Your work's got to make it through free-flowing peer review research, and not pork from the Congress. And this has hurt the NASA program. Nobody's bad, but sit in my office sometime and you'd throw up from the calls you get from the Hill. Good people on the Hill, because people are trying to maintain the status quo, and the NASA team is bound together and determined, never again.

So, we have a shared vision. We're going to look at the planetary system, not as planets in our solar system. We're going to look at the planetary system as every possible planet that we can see with the aided eye. And we intend to do comparative planetology. We intend to get ground truth from what we can see with robots in our solar system, to what we can see, where appropriate, with people who walk on planets in our solar system, or we can see remotely in nearby suns.

So what we have done is, we have taken the program responsibility away from NASA Headquarters. It's gone, it's finished, it's done. We actually trust the people in the Field Center. We've identified lead Field Centers functions, and we're out of command and control. [No longer will people patrol the halls at NASA Headquarters, looking for hot dog stands. We're shutting down every scientific hot dog stand, and everything must be related to the strategic plan for NASA, and everything must be related to answering basic questions.]

[And we're open. We want the scientific community to come back at us and say, "Hey, we don't think the questions should be this way, they might be that way. But we're communicating with the American public, we're online on the Internet- we get an unbelievable amount of hits- and we want to work together."] [We've got to close all these hot dog stands because as our budget comes down, it's not allowing us the kinds of research that need to be done. So for our part, Headquarters will no longer be measured in multiple thousands of people, it's going to be measured in hundreds of people. Good people are going to go to the Centers, and good people may no longer be with the Agency.]

I don't want you to feel there are bad people, but this is a fundamental change in the seascape. Headquarters will determine the what and why, centers will determine the how. We will not usurp the responsibility of the lead center and directors. Engineering is going to be short-cycle time. As a general principle by exception, we won't start programs beyond three years from the start to launch, unless there's some real compelling reason. We'll demand that all the technology get done in advance. You could have

experimental programs, you could crash x-planes, you could do whatever you want. From the point you start to the point finish, unless there's some rule of physics that says you have to, three years. Low cost; each mission has to be less money than the next. Because our budget's coming down and it's not even getting corrected for inflation, and we want to start new things every year, and that's how we'll do it.

We will have a technology pipeline. In the past, every program had to have their own technology, and now we're setting up the technology pipeline for launch, setting up the technologies pipeline for spacecraft, and we're not going to fund technology on a hot dog stand basis. It will all be covered (inaudible) based on (inaudible).

And it brings to mind a question a young engineer asked me. I was in the job maybe about three or four days. And this young engineer said to me, "Mr. Goldin, I have a problem. I found a new device that no one will fly. I go to the program managers and they say, has it flown before? And he says no, so they say to me with a pat on the head and the back, go away young fella. Go get it flown and then I'll fly it." You know, how is a Catch-22? Well, we are now setting up a series of spacecraft that are going to be technology directed, so we can test these new technologies out so when we go into the missions, we don't have to have risks.

This is the concept and, I'll tell you, I've got to thank one person in this room here, Jerry Pourvelle. He came to me early in my tenure he talked to me about this experimental concept and a number of others. Really competitive things, and I probably (inaudible). So we now have the tools, we now have the approach, and now we have the planetary approach that's broadened out.

So how do we go at it? I propose that you consider that there be four phases to planetary exploration. I'll call Phase 1 Robotic Precursors. This is where you can throw flyby, orbiters, landers, rovers, sample-return devices, to kind of scout the land. To find the places that have some real potential. Phase two would be Initial Human Exploration. That first few flights. You don't have to plan it for a whole long series. Just the first few flights.

Then as you get more data... the cost benefit ration starts getting better... the potential for scientific resources or commercial resources appears, and as the cost goes down that ratio is really sharp. You then go to Robust Human in the exploration. And then finally, you go over the threshold, to phase four, Sustained Human Presence. I think we need to think about these different thresholds because we mix our metaphors. When we talk

about missions- "Hey, I want to go to Mars"- what people generally say is, give me the price for that first flight. And that's unfair to the President and that's unfair to the Congress and that's unfair to the American people. And these phases have a hierarchy. It's a resolution of spatial, temporal, spectral, analytical, and adaptability to tools.

Let's take a look at them. The lowest spatial resolution, the lowest spectral resolution is going to be from telescopes on the ground. We've done it for centuries. And the first big leap is to take the telescopes off the ground and put them into space, and get rid of the Earth's atmosphere. Ultimately, the telescope's going to have to leave earth's orbit. We're going to have to put the telescope out at about 5 au, so we get rid of the zodiacal light, if we ever want to look at planetary systems around nearby stars.

And then you get better resolution by going through a fly-by and that's what we did with Mariner II to Venus. And it opened up our eyes. Then we orbited the moon, the lunar orbiter in the Mariner series. And then we landed the Surveyor and Viking. I mean, that was it. [We haven't landed on a planet for 20 years now because we've been so excited about the service support contracts on the shuttle that we're not doing science. We spend \$10 Billion on the space station and didn't produce a piece of hardware, but boy, did the contractors have fun.]

[It is shameful; it's stealing from the American public, and these are good people, but we have a bad system and we've got to wipe out this bad system.] And we're getting there. We've made tremendous progress. And then after we land in fixed positions, we've got to roll. We're not going to wait two more decades to roll. Within days of the time that the Mars Orbiter was lost, we started the Mars Pathfinder. At one-quarter the cost, we're going to land a rover on that planet that could move around without command from Earth. We say, go from here to there, it will figure out where the rocks are and will go around the rocks. It has its own eyes and it has... I don't want to say a brain, but it has a reasoning capability, and that whole rover may have cost \$10 Million. Maybe 15. It didn't cost a good fraction of a Billion dollars. And they're building the whole thing in three years, and if they launch it to Mars and it doesn't work, I'm going to hug that team for having the courage to do it, because I want people to take risks. Spacecraft are less expensive, and we could afford failure because we've got to push the technology in these areas.

And then after we rove we bring back samples, or we can put an instant new lab out there like we had the Viking biology life detection experiments. That trade isn't very clear to me. I think it will probably make sense to bring the samples back so we don't have to miniaturize a

chemical and physical lab (inaudible). So Stardust is our first sample return, and we don't have to wait until the middle of the first decade in the next Century to do it. And then clearly, you've got to put people on the surface when we find out that we exceed the threshold of the cost/benefit ratio.

Apollo was enabled by the technology of Saturn and the Lunare Excursion Module. Jack Schmidt found active volcanism there because he saw orange glass. Now people say to me, "Dan, why don't we send rovers? Why don't we sent robots to do this work?" To which I respond, the minute you show me a robot that roves the earth doing geophysics, is the very moment I'll send a robot, at 10,000 times the price, and put it up on a planet. It doesn't have cognitive ability yet, it doesn't have versatility yet, it doesn't have manual dexterity yet, and it doesn't have adaptability yet. Now, maybe when some of these robots come into being, we won't need people for that aspect, but we still need the cultural aspect. And people are going to inhabit other planets at some time. I don't know when, and it won't just be robots, it won't just be robots.

So the challenge is to figure out what are these cost/benefit thresholds between Phase I and Phase II, Phase II and Phase III, Phase III and Phase IV. And it could be scientific, it could be economic, and it could be cultural. And I say, we should not ignore it. I'm not saying overplay it, I (didn't say) (inaudible) do it for money, but if there's a commercial benefit or scientific benefit, people of the United States or people around the world are going to pick up the bill, and we've got to factor in communications that do not put science into a black hold.

And I want to tell you, we've made very little progress since I begged this organization a year ago, to get the scientists to start communicating with the American people. We haven't made progress. I've probably been in 20 or 30 cities since I gave that speech and people are still saying to me, I'm not seeing it. You need to do better, I need to do better, we need to do better.

Now, let's take a look at some of these scientific benefits. And again, you can make your own list, but I've made mine and I'm speaking about it so you can decide whether you like it or not. First, and probably one of the most compelling, are there present or past forms of life at any level. If we could find a fossilized, singular-cell life, it would change a lot about how we think of ourselves. How is the planet structured and how did it evolve and what are the implications to the earth's evolution or general theory of evolution of the earth? Can we unravel the body's climatic history and environmental history so we can better understand our model for the

climatic understanding, because when you start doing climatic experiments you need a laboratory the size of a planet. You can't get some of these performance parameter inside of a laboratory of planets.

From an economic standpoint, the most compelling issue is, can you find resources to live off the land? And in fact, if you ever want to get to Phase II from Phase I, you must have that, because it's going to be too expensive. As Bob Zubrin points out, the load-down of spacecraft with all the breathing gases, all the fuel to go there, to stay there and come back. So I would say it is my intuitive feeling that you almost have to say finding resources to live off the land has to be a condition to go from Phase I to Phase II.

Second point on the economy is, are there natural resources in the broadest sense, of economic value? Are there environmental conditions conducive to manufacture of high value products, because the environment that you have there gives you unique ability (inaudible) performance better than what we have on earth. And there are a whole variety of parameters (inaudible). And maybe, just maybe, Tom Rogers, (inaudible) reality.

Now, when you think about geological fieldwork, and you look at this article in Time Magazine, you know, the geologists made... the paleontologists made a trade. They took a look at Landsat pictures... perhaps, I didn't get into their brain... they took a look at other things, and they saw there's some places in Australia that offered some promise. Did they send a robot to Australia? No, it was a cost/benefit to get a plane ticket and rent a car to go to the site themselves. And they went to this. In other cases it made more sense to send a robot, so when they went to the bottom of the ocean to make some of those measurements, they sent a robot.

And this is okay. You don't have to have robots and you don't have to have people. But you do this horse trade so that it makes sense, and then you proceed forward instead of making macho statements saying, "I'm going to go, follow me." That's what happened with SEI. President Bush genuinely believed this was the right thing to do and to me, NASA let him down. We led him down the garden path because we didn't tell him how much. How much was a quarter to a half trillion dollars measured over 30 years? You know, it dims the light on the gross domestic product. This is not the way to do space science. So we need to really think through this cost/benefit analysis.

Now, let me define what I mean by the life zone, because I know there are

those who say the only place to go is Mars. It may be the only place to go, but if you think about what the definition of the life zone is in the broader sense, I think we may open up our minds. The life zone is not the range of distances between the sun, where conventional thought says that water will be stable... where it won't boil and it won't freeze. It's much more encompassing. It's a multidimensional space of temperature, pressure, composition and time, in which conditions necessary for life could, does or did, occur. Very important to think about that.

So the robots have begun to explore what that life zone is in our solar system and they'll define the life zone... they've begun to define the life zone in another solar system. The earth, we can go down to Antarctica. Chris McKay is here, he's done that. It helped us to figure out where to go on the Viking, except the data came two months after we launched it, so we went to the wrong place to search for life. You know, we look at the deep oceans and we see other characteristics and we look at Australia. Now, Mars looks like a place that might be right, and we all know... most of us know the arguments about Mars: it might enough water, comets and asteroids could have landed there with the building-blocks of life, there are dry lake beds. There are all the conditions conducive that life could have or might exist.

And we're going to begin to get a sense about that. But we have to look at complex environments- at the interplay with geological processes, chemical processes, physical processes, biological processes, and a whole host of transport processes. And these are the things that produce the conditions we can't always predict or imagine.

Now, let me pick a wild and crazy one. In the summer of this year we fly by Europa. First blush from Voyager says it had these cracks that come and go. Maybe the ice is healing itself. And then when you take a look at it, the gravitational pull could be putting enough energy into the core of this body that we might have an energy source. And then if you look at the density, looks just like a chondritic meteorite. And that has building blocks of life. So if you look down to the earth's ocean's floor, in the deepest channels on earth, maybe we might find the kind of life there that might be on Europa. Who knows? I don't know. But I certainly keep an open mind and when we think about where we're going to go next, I have deep respect for what I don't know about. But who knows, it might have a 10-kilometer thick ice crust, on a 100-kilometer deep ocean. Who knows?

Venus, maybe billions of years ago, could have been in the life zone. Today it's not.

The Moon. What if the Lunar Prospect finds ice at South Pole. Who knows? I want to tell you, there's going to be one beeline for the moon. All sort of possibilities. Maybe Titan... Cassini, once it's there in '97. And as Gene Shoemaker points out, water abounds on the near-Earth asteroids. There could be a wealth of possibilities in those asteroids.

And then, not only do we have the possibility of life, but we have the possibility for some ground-truth. Think about Europa, and think about the moons that might exist around these planets that we just have found. What if we get some ground-truth? We have to understand life here and be open and imaginative. Let me just give you one little speculation. Let's say we find an earth-sized, blue-green planet. You say ah, we found life. What if we found a blue-purple planet? Should we stop? Maybe we've got photosynthesis from rhodopsin, and maybe life might be the same, except it's rhodopsin instead of chlorophyll. So we have to keep open minds.

So the possibilities are great but there are limits to what we can do. The NASA budget's coming down, and before we can even think of stepping foot off this planet, we have got to fix, the festering, nagging, shameful problem that we have in this country in launch vehicles. I'm embarrassed, I am part of the problem. I feel we have not served our country well, yet every time we go forward with a new launch vehicle, the scientists are worried about their programs. I'm here to tell you, scientists, that unless we have a launch vehicle there will be no science-that we can no longer afford \$10,000 to \$20,000 a pound.

And I testified under oath before the Congress that the highest priority for a new start at NASA, was to fix this and go on to a different problem. Even if the budget comes down, we will cancel programs. Never again are we going to pay the price we paid for redoing old ballistic missiles that my company system system engineered in the fifties. I'm embarrassed for our country. Good people have been living with the status quo, and if this doesn't change, we can talk all we want about space, we can talk all we want about interferometry, we can talk all we want about instrumentation, but, we must have new launch vehicles. And it's not going to happen with an organic program. Let's throw \$10 Billion at it. Design a little, build a little, test a little. I'm going to keep the program small in size so no one will get rich immediately. The place to get rich is after you figure out how to do it for an order of magnitude of less money.

(1st tape ended, tap gap)

After you get into that shuttle, for two minutes there's nothing we can do

for the astronauts. All they can do is bail out.

But we've got to be honest with the American public and not deceive the American public that they're getting something that they're not getting. They can no longer afford billions of dollars a year with tens of thousands of people hugging the shuttle. There are some people who think the shuttle is the ends, not the means of the program at NASA. Now, it's a wonderful machine and we're going to make that machine as safe as humanly possible. In fact, the reliability on ascent in the last three years has (inaudible) because we invested money to make it that way so the astronauts would have more confidence getting in.

But there are those who think they're going to keep the shuttle program alive to the year 2025, and I want to tell you, they're whistling Dixie. Unfortunately, this crew is in agreement. Come to an AIAA meeting and you'll see the frowns. I mean, we are taking money from science and putting it into bureaucracy. Where is it said you need 20,000 people to build a launch vehicle? But given that fact, I'm proud that we have a safer vehicle with a million dollars (inaudible) of new investment. This money helps fuel (inaudible). So that's the first item on my list, and probably the second, third, fourth, fifth and sixth. That's the only way we'll leave this planet. That's the only way we can do a mission like Gene Shoemaker proposes.

Then we have to second, figure out how people could live more safely and efficiently and productively in space. You can't take people in a 1 g environment and throw them into cosmic solar radiation, zero gravity, and say have a nice day. There are fundamentals of life science that have to be undertaken, and this is where we as an Agency, must nod to the medical science, life science, biotech (inaudible) all the communities in this country. NASA will no longer be about rocket boosters when we fix that trouble. NASA's going to be about life sciences, about how to medically select and protect solar flares, cosmic radiation, life support. How do you control microbial elements for two, three years... it's a very small environment-without getting a Legionnaire's disease. But if you get Legionnaire's disease, what do you do? How do you make a personal life support system? A space suit that doesn't cost \$10 Million. It costs a good fraction of a million dollars every time you use it. The object of the EVA suit is not to make people wealthy or give them jobs. The object is to protect the vehicle activity.

Microgravity affects the heart, the muscles, the bones, the immune system, the nervous system. By studying how to get countermeasures to them, we'll better understand human physiology so we can enhance the quality

of life on the earth. We need new concepts in medical care. You know, on Apollo we invented intensive care monitoring, and some of the people in this room have had to have these little battery packs you carry around. Just about this big, looks like a transistor radio. We intend to put that on a microchip that you can't even see, using nano technology. And in fact, right now some of this technology is being used at the University of San Francisco to put implants into children that are still in their mother's womb so you can monitor their vital signs (inaudible) and perform surgery. So it's not in the future. It's here. Chemical surgery, select and induce resistance to illness. Telemedical Support to enhance diagnosis. These are going to be done in the space station and ground support.

This is science, this is important science. We have to figure out to make robots and how to integrate them with humans. We are on a path to develop robots that think, see, hear, touch, smell, speak, talk, perform mechanical operations. Right now we robotics assistants. By the time we get done with the space station we intend to have robotic surrogates (inaudible). And we're going to test them in space. When we put the astronauts in space they're not going to do into space with a 400-pound space suits and at least 10,000 hours of pre-breathe.

Third, we need tools to produce higher resolution spatial, spectral, chemical, and to cut life cycle costs, science space-based infrastructure. And here is the concern. Let me use the Hubble space telescope as an example. Hubble is as safe as every other telescope we've put in space. Because we've built telescopes on the ground with (inaudible) huge pieces of heavy glass, we said uh-huh, when we build a space-based telescope we'll do the same thing. And then on the ground, because of gravity, we need an ultra-stiff structure. I mean, sort of I-beams for a metering tress. So we made this thing so darned stiff that you don't have to worry about any problem.

So then what we do is, we take the same technology and we try to put it on a launch vehicle. And so we get a \$6 Billion, 25,000 pound wonderful Hubble telescope. What we need to think about, and will open our mind, is instead of rigid trusses, get the rigidity with laser beams. Use floppy structures and go to adaptive structures to correct dynamic problems and cause these static problems. Control the surface of the optics so you don't even have to test it on the ground, and figure out how you take this floppy thing, put it into space, deploy it, have it adaptive control. Now, I'm not talking about tomorrow, but we've got to leave our old ways if we ever expect to get a factor of 20 to 30 reduction in cost (inaudible).

Now, I want to tell you, I just read a ski magazine. K-2 Ski's has the

following ski which I will buy next week when I go skiing in California. It has a ski with a piezo-electric device, so when you go over bumps you build up a charge on a capacitor which then gets dissipated, and the result is the skis don't vibrate. Now, if K-2 can build a ski to do that for a few hundred dollars, we ought to be able to build an optic twice the size of the Hubble Space Telescope. An adaptive optic. We ought to be able to make that one-tenth to one-thirtieth the weight, and one-tenth to one-thirtieth the cost, and all of a sudden we could see anything we want to see. Maybe out to (inaudible) light years. This is important stuff. And then, instead of grinding things, we ought to replicate surfaces, and instead of grinding and polish, we ought to think focus. It's a whole new way of thinking, that you can apply this active control of large space structures. And they're building systems in space with zero G precautions.

Now, the first task that I talked about, the lead center is NASA Marshall. I told them, shut the hot dog stands down, and all you've got to do is work within this framework (inaudible) academia (inaudible). NASA Johnson's been worried about operating a space station and figuring out how people can live and work in space. JPL, worked with academia and industry, and resolved this problem.

The fourth problem is probably the most difficult, and not necessarily the least priority. There's revolutionary change in design, simulation, and analytical tools. We're in the dark ages because of tools, and I ask you to think about this. We have inhomogeneous, non-isotropic materials. If you fail a composite it doesn't yield, it explodes. We have complex environmental inputs, we have stochastic processes and non-deterministic systems. Now you mix all this stuff together in a ball and say, where's my design tool? It's non-existent.

First of all, if we're going to work with composites in some of these (inaudible) materials, we need a physics-based design tool to start with the individual molecules and the forces between them. It builds up (inaudible) design (inaudible), and started (inaudible). But this is the type of thing we would hope we have partnership... this is a perfect job for academia. This is the kind of thing that needs to be done. We have these design tools... we design in black plastic, do you know what I mean here? Black aluminum, design in black aluminum, you know, when you take composites and you do safety factors like you do in aluminum. But it's non-elastic. It's not isotropic. It doesn't make any sense. Beechcraft tried that with that starship, that's why it failed. They designed in black aluminum. The University community needs to work with us to build these physics-based tools.

Then when you think about what has to be done when you get adaptive, intelligent, learning, self-generating, software to deal with the chaos and the sheer magnitude involved in (inaudible). And then we need computers to go along with that. And maybe in the limit we go to wet computers. Genetic-based algorithms could provide stable, state change of complex systems, and we are working on this. The other problem is, travel is too expensive. People get on planes, still today, because we don't have geographically distributed user-friendly tools to allow collaboration. So we need interconnectivity, interoperability, wide band width, with common media and low cost.

We have just changed the mission of NASA Ames. I told them, stop hugging wind tunnels. Let go. Let's take the science mission at NASA Ames, and turn it into an institute, and let's focus NASA Ames, that's right in the center of the information capital of the world, into the center of excellence of information and technology in the world, so we can develop these tools. And we're starting... we're working with the entire industry, we intend to have a virtual laboratory for developing multimedia tools right now for doing these kinds of tasks.

So these are the type of things. Now, anyone can make their own list, but I think these things go to the heart of the problem, and these issues get back to scientific fundamentals, starting at the beginning with the molecules. So I'm highly confident that we'll be able to do all the things that one can name in one vision.

Let me ask you to think about this. A few decades from now a young lady, who is the daughter of this Bell Atlantic technician, will be the director of JPL. (inaudible) And she's going to be sitting in her office and she'll be looking at a number of images in this picture-framed video display on the wall. And she'll be looking at direct detection and analysis of some planets, and she will have seen a planet, and if we didn't have enough resolution to see ocean and continents and clouds, but because the planet was spinning we had a few pixels, she was able to discern some ice caps, she was able to discern some temperature variations and (inaudible) characteristics.

And she also took the data in an office where the mission that she helped lead, before she got that job, to land the first human on Mars, in the first demonstration phase of the mission. So perhaps, just perhaps, something would happen. She was waiting, the phone rang, and the NASA Administrator called and said, don't come to Washington. Turn on your screen. I've got to show you something. Perhaps they and the rest of the world sees something that changes history. Something that changes what

it means to be a human being, and perhaps, just perhaps, they would see something that suddenly and forever changes everything. Thank you very much.

(Q & A session with audience)

Q. (inaudible)

I have not spoken to him.

Q. (inaudible)

I understand. I mean, I try and talk to as many people as I can. I'll be happy to talk to him.

Q. (inaudible)

I understand, and, I will do that. I will take it down, and if you give me a card, I'll tell you what he said.

Q. (inaudible)

What's that?

(inaudible)

Oh, Time Magazine (inaudible) my eyes are old eyes (inaudible) it looks like December 4th, '95. (inaudible) has good eyes.

December 4th, It had it right. Yes sir?

Q. That's an inspiring vision you sketch, but you're not going to (inaudible) the space station (inaudible) could you expand on that for a bit, please?

Well, I appreciate your comment, and let me respond to it. The space station is being built to see how people can live and work safely and efficiently in space. Now, if you want to test someone at zero gravity, you can try to do it on the earth and you get 28 seconds if they go in a ballistic parabola. If you want to expose someone to years of zero gravity and get real (inaudible), real sophisticated medical devices, the only way we know how to do it is to go into an orbit that keeps falling. And we know an orbit we can keep falling by going into orbit around the planet earth. If we want to go test robots in zero gravity, we don't know how to do that and have those robots interact with human beings for 29 seconds.

There are a whole host of issues. If we want to really test how to contain samples and bring them back to earth (inaudible) because if we bring back specimens (inaudible) there are a whole host of microbial (inaudible). You can make long, long lists, so, sometimes people think about, oh, the justification for the space station is to do microgravity and life sciences. The justification of the space station is to figure out how people can live and work safely and efficiently in space.

That's something we have to do, and then because we set up this unique facility... we have 100 kilowatts of electricity, we have a pressurized volume equal to the size of two jumbo jetliners, we have 14 of the most

developed countries of the world participating, we have six researchers on board, probably one and a half will be tied up with maintenance. We can do stunning science, I want to tell you. Even in that domain, even though that isn't the justification, we are getting stunning results. Biotech to biomed to materials. Testing Nobel prize theories. The theory of phase change. So it is there.

Now, the point I want to make is, the reason the space station got into trouble in the first place and we kept debating it, it is no longer a debatable issue. We are going to build the space station. That's why we spent \$10 Billion in 10 years and got nothing, because NASA tried to please the Congress. A responsible parent sometimes says, "no". We're saying "no" to redesign, we're saying "no" to changes, and we're going to build a space station. We are less than two years away from launch. Now, we set that schedule in October '93. And unless there's some act of God we can't control, we're (inaudible).

We have a reserve, and the other thing we did that's unique is to set aside \$2.6 Billion reserve for science. Engineers cannot touch one nickel of that science. The problem we had is we had a solution seeking a problem. We now have a problem seeking a solution.

And the other thing I want to tell you and this gets back to a point that was made with Gene Shoemaker in a press conference, someone said, Gene has an idea for a mission to an asteroid. Will you approve it? I got a little cute and said "no". What I really wanted to say was, we have these thresholds to go through, and if Gene can make it through the process, and it will be a peer review process- it will be a national peer review- if he makes it through, and this is the priority in (inaudible) mind. Now, his argument is, it's less expensive to go to an asteroid than it is to go to the moon because there's almost no gravity on the asteroid and you don't need delta-V going down and going up. And he says the scientific riches on the asteroid has great possibilities.

Now, one of the things I didn't talk about was, we would like to have some demonstration missions instead of just pausing between Phase I and Phase II. Real quick how cost missions to prove out the technology and safety. And one of the things I did was, I challenged the folks down at NASA Houston. I said, it cost \$11 Billion on a current basis in FY94 dollars to go to the Moon on Apollo. I give you the following Gedanken experiment. Go to the Moon... you're getting no money to do this study... (inaudible) figure out how to go to the moon, land two people on the moon, keep them there for three days, bring them there and back safely, no other requirements. And then I said, figure out how to do something similar for an asteroid but,

number one, something in the range of a factor of thirty less than Apollo on a recurring basis.

They weren't afraid. And right now, we'll see how they go. I wouldn't want to... I don't want to usurp what they're going to say a year from now. And I said, no outside contractors, you can't have thousands of people. I want you to sit in a room, I want NASA to start getting technical instead of being contract managers. And then we'll ask contractors to do this later. But I want to re-establish the pride and excellence of NASA. They told me that we could go... and I had fun doing this also (inaudible) Apollo was 136 tons in their calculations and they could go for 26 tons (inaudible) . Very different.

But you know what they said? The thing that's killing them is launch services. And that's why when Gene... someone said, well, will his asteroid mission go, the sooner we get margin of control I feel will get (inaudible) asteroid. He may (inaudible) that may be the very first mission we're going to perform, and that's administrative (inaudible) technicians, I tried to. Thank you very much.

NASA Administrator
Daniel S. Goldin

AAAS
Baltimore, MD
Transcript
2/9/96

It's really a privilege to be here. I spoke at the gathering last year in Atlanta, Georgia. I talked about the author's task of communicating numerically. The criticality of the scientific community not looking into itself would recognize that the American public is picking up the bill for all the science that we do, and sometimes in the joy and passing what we ~~would get~~ ^{forget} that the ultimate consumer of science and technology that we're working on for the American public.

And a hell of a story about the American public, (inaudible) ~~it's got to be lowered~~. And this story takes place in November of last year. My wife and I had just moved into a house up on Capitol Hill and I was trying to get the phones hooked up. I got the phone line hooked up but I couldn't get the fax line hooked up and I was feeling kind of naked at the time without my fax at home. So we arranged for a technician from Bell Atlantic to show up at our house at 9 o'clock on Thursday morning, which was I think, the week before Thanksgiving. And it ^{was} clear why I would be ~~there~~ ^{that} at 9 o'clock, ^{that} was I was non-essential and the Government had shut down. So my wife went off to work and made sure I took care of all the chores in the house.

~~So that was the~~ (inaudible) ~~It~~ was also an interesting day because at 11:10 that day I was going to communicate with the International Crew on Board the MIR, from my house. And I had refused to go into NASA Headquarters because we were on furlough and I felt it inappropriate that the Administrator bring in the crew in the TV studio so I could talk to them, so I just asked Mission Control, can I make this call from my house? And they said, sure.

So 9 o'clock passes, 9:30, 10 o'clock, 10:30. A few minutes to 11 the doorbell rings and there's this big, tall guy at the door and he can hardly speak English and he says, hi, I'm from Bell Atlantic. I'm here to put in your fax line. I said I know, but I've got something important to do. So she says, "I can handle it real quick, don't worry." So I opened the door, he goes dashing into the room, he says, where's the plug for the fax line? And in our kitchen we have two plugs, one for the phone line which was alive, and one for the fax line which was dead. So he immediately injects his tool into the fax line and Mission Control's calling me and they hear, whoo, whoo, whoo. (inaudible). So I said, could you pull it out, please? He says, "Not to worry. You've got a few minutes before the phone call." I said this is a very important call.

So finally he pulls it out. It's now five or six minutes after 11 and Laurie Boeder who is the head of Public Affairs, came to my house so she could ~~(inaudible)~~ just to see what was going on. And by this point in time the tears are just falling down ^{her} my cheeks, it's so funny. And I didn't want to tell him because I felt he wouldn't believe it. So, he says, I'll tell you what. If you don't want me to work in the house I'll go to the switchboard outside, ~~(inaudible)~~ and I said, please don't. So it's now 9 minutes after 11, we're all getting kind of nervous, so I said, here look, why don't you sit on this couch next to Laurie? And I turned on the TV and there are the astronauts floating around ^{and the} in all different flags, and he still doesn't get it.

So I said, I'm going to talk to space. He rolls his eyes. ^(laughter) And then he hears my voice coming through the TV. The guy about died. [^] And it was really an historic event because we sent the shuttle up to a Russian space station, we had a Russian on board, a German on board, we had a Canadian on board, and the Americans. I mean, this was almost a representation of all the people ^(above) the space station. The only people that weren't represented were ^{Japan} ~~the Finns~~. I mean, it was really an historic mission.

And I was still ~~(inaudible)~~ I mean, I was still ~~more~~^{all} wrapped up in the mission. I didn't appreciate this until, you know, I thought about it afterwards. And then he listened to it and I mean, this man ~~(inaudible)~~ ^{was glued to the} TV. And when it ended I said, what did you think of it? And he said, you know what? Space is ~~what's~~ about my children's future. Those were the

only words that he could get out of his mouth. And here's someone who's relatively uneducated, new to this country, but he understood the criticality of space in the future of his children. The connection was right there.

And sometimes when you're inside the beltway and you listen to the cynicism that comes out, you don't appreciate that America wants to open the space frontier. People on this planet want to open the space frontier, and they're sick and tired of bureaucracy getting in the way.

And after that experience, all of a sudden there was an unbelievable sizzle that took place. Galileo got to Jupiter. I mean, if you think about the probability of that happening, the Perils of Pauline. And then the miracle of the incredible brains of the people that designed that mission, it's breathtaking. You know, the margin for error, assuming everything worked, was so unbelievably low, that you ask yourself, how did it happen? And then shortly thereafter, I turned on the TV and there's an excited newscaster showing a picture of Deep Field Galaxy. And I mean, as excited as could be, (inaudible) as excited as anything happening in, you know, Bosnia, in Haiti, over the budget.

And then I had the opportunity to talk before the American Astronomical Society a few weeks ago in San Antonio. And I was going to talk about origins, and even though we're talking about humans in space I'm going to talk about the origins ^{program} ~~appropriate~~ today ^{and to} put it in context. And before I give a talk I like to, if I have an opportunity, talk to some scientists involved, so I had dinner with a number of scientists. ^{Geoff Marcy} ~~Jeff Mossey~~ was there and Alan Dressler -- a whole bunch of people. And I was all excited about talking about ~~talking about my subjects~~ ^{Geoff Marcy} and halfway through the conversation ~~Jim Mossey~~ ^{Geoff Marcy} says to me, "Do you know what I'm going to talk about tomorrow?" And I said, no. And he whipped out this data showing he had found two planets circling stars within 35 light years of Earth.

I mean. I couldn't believe what I was looking at. And these planets were in the ^{quasi-} ~~fuzzy~~ life zone, (inaudible) And I'll talk about ~~that~~ ^{that's} (inaudible) I want to define that a little later. So, if you think about it, if we can pick a time in history, all of history, you say, when do I want to be alive and when do

I want to be there? It's in 1996 and '97. I don't know if you realize what's about to happen. We are finally getting a chance to open the space frontier, (inaudible) Now, there's some things we've got to fix, but you know, you talk to some of these people, they say hey, wait till you see what I'm going to show you next.

This is unbelievable. It's the type of thing that (inaudible) they want to put ~~it~~ on Nightline. So instead of worry^{ing} about the budget, why ~~you know~~, we can't work as Democrats and Republicans, as Americans together, here is something that's definitely superior to this whole thing. But we're not stopping. We have resources up there, we have resources on the ground. Next week we're launching ~~a MIR~~ ^{the NEAR} space ~~craft~~ ^{crew}. We started on it three years ago. We didn't debate it. We just started the program and we're building it, we're launching it on the 15 February, and it's ~~being~~ going out to an asteroid, and it's going to ~~go into~~ orbit 20 miles above that asteroid and we're going to learn almost everything we ^{wanted} ~~have~~ to learn. I know ~~John Gene Schumacher~~ ^{Gene} still needs some more data, and I'm sure we'll find some more missions for Gene.

And then this summer we're going to launch the Mars Global Surveyor and the Mars Pathfinder. Three years. ^{We'll launch} Half the price of one Mars Observer, which disappeared. Every time I go back to California they say, have you found Mars Observer yet? ^{A large lunar prospect} ~~A large lunar prospect~~ in '98. We want to see if there's water ^{at the south pole} ~~in some form~~ (inaudible) ^{that might be the most} ~~valuable~~ water anywhere in the solar system. ^{Cassini is} ~~'Cause see, it's~~ being launched earlier than we initially projected. Close to a billion dollars less money. That's why we launched in October '97. No launch start (inaudible) ^{Cassini} ~~Cassidy~~ is going to go to Saturn (inaudible).

We just started a program, I think a month ago. It's called Stardust. We're going to go out and collect dust from comets and then separately collect intergalactic dust. And ^{then} ~~that~~ the samples are coming back to earth. We're going to launch that spacecraft ^{in three years} ~~(inaudible)~~ We just started it. What if we find some building-block of life in ^{those samples} ~~(inaudible)~~ What else might we find?

And then in the summer of '98 we're going to launch Deep Space One. I made up the name. I didn't know what else to call it. Kind of feels good.
(laughter)

We are going, for the first time after 30 years of development, utilize electric propulsion. Absolutely crucial for the exploration of space. Real advanced sensors are going to rendezvous with a whole bunch of small bodies. And then, Mars. In '98, launch a global surveyor, Mars Lander II. And maybe even Mars Penetrator I. Then went to get to 2000 Deep Space II. This is going to be the first experiment in ^{interferometric} parametric techniques in space based upon work we're doing with KECK and on Mount Palomar in the ~~parametric~~ ^{interferometer} with Keck-2 and on Mount Palomar to ~~prepare for the Keck-2 interferometer~~.

We thought the problem was going to be ~~meet~~ ^{the beam -} forming networks and the ~~ne~~ ^{to within a pico-meter,} metrology, knowing where things are, when we land. People (inaudible) and having pointing accuracies of a fraction of a micro-second. That's not the problem. ~~although we don't know~~ ^{I'll talk about} what the rest of the problem is. But these are on the books, and we've put them on the books even though the NASA budget's coming down. Someone there in the press conference said, "NASA's coming apart." I don't understand. I just don't understand, because people in the past measured the vitality of NASA by the dollars going in, by how big an organization they had, by how much paperwork they had, and how to ~~(inaudible)~~ ^{satisfy} by the bureaucrats in Washington, how much punishment could they inflict on the nation? ^{later}

I'm proud to say our budget has come down. We started 25 new programs with 20,000 less people in this great government. And there's going to be another 35,000 less. And I feel on a human basis, that this is a vital and alive program. (~~Apollo~~ ^{Hubble}) is going to be up there, and next year, just about a year from today, we're going to put in ^a UV spectrometer, and we're going to put in ^{about} a near-IR imaging spectrometer. Think what's going to come out of Hubble. And it's not going to be done without people. They're going to be astronauts ^{who} to do it, and I'm proud to say there are going to be astronauts. And we're working ^{with} through the KECK Foundation; ~~and~~ we're helping build KECK II and this May we're going to dedicate it and we're going to start getting first light in October of this year. ^{ATT}

And then with the data from the Mount Palomar ~~interferometer~~ ^{for} we're going to update the ~~meet~~ ^{beam} forming at the KECK Observatory in Hawaii. And when they get the ~~parametric~~ ^{interferometric} measurements we'll begin to get some sense about extra-solar ~~of valuable light~~ ^{zodiacal light}, and hopefully we'll detect ~~up~~ directly

(hyphen)

Jupiter-class planets.
~~for the planets~~

1r 6

from the ground, a whole bunch of ~~nuclear~~ ~~(inaudible)~~. And again we'll move forward. And then we're going to study the earth's environment. We're going launch the Lewis Spacecraft, the Clark Spacecraft, the T~~RMM~~ Spacecraft, Top~~ex~~ a follow-on.

I noticed our French friends here. EOS~~AM-I~~, EOS~~PM~~, Landsat, Sea Star. These are all going to happen, and starting in '99, every year we're going to launch a new earth science ~~probe~~ ~~(missions)~~ ~~(inaudible)~~. So it's amazing that for less money things are happening. We intend to open the space frontier, not to provide jobs for people ~~in the industry~~. Not to provide jobs for bureaucrats and not to provides jobs for bureaucrats in universities. Perish the thought. They're there too, 'cause they're not just in the government. We want people to work with us who want to open up the space frontier. This is not just intellectual. It touches the human spirit.

of Time magazine.

I took with me two issues ~~(inaudible)~~ I mean, I read lots of publications. I could take bunches of them, ~~(inaudible)~~ But look, here's Time Magazine.

The cover of Time Magazine. Not about death and killing. It says, 'Is anybody out there? How the discovery of two planets brings us closer to solving the most profound mystery in the cosmos'. This says there's more to life than survival, that as human beings we need intellectual

nourishment as much as we need food, as much as we need shelter. And it's built-in to our culture. And even more stunning, this is ~~(inaudible)~~ ~~another Time magazine.~~

I don't have my reading glasses on, but I think ~~this is~~ ~~it's from~~ December of '95. It says, 'Evolution's Big Bang'. If you haven't read about it in either this or any of the scientific journals, there ~~se~~ been some new findings. That in a 10-

million-year period, about a half-billion years ago, it seems everything happened. We went from a single-cell ~~organisms~~ to a most complex structure. ~~One.~~

And if we have a sample of one planet earth, I'm not sure we'll sure we'll ever be able to answer why. And for that reason alone, and I'll talk about many others, we need to explore.

So we shouldn't worry about just the day-to-day things because they'll get taken care of, believe me. We have 535 people in Washington worrying about the ~~day-to-day~~ ~~activity~~ ~~ies~~. What we have to do as scientists and engineers is think beyond the next fiscal year, beyond the next quarter.

~~We have to think~~ ~~what's happening~~ 20 or 30 years out, so that Bell Atlantic technician is

assured that his child will have a real future. This is what drives me. I mean, every day I have to pinch myself and say, oh God, look at the job you've got. What a privilege that the President of the United States lets you to ^{come in to} ~~go to~~ work each day. And each day I say, whew, I made it through another day. He may decide not to. And that's been known to happen.

So what we have to do is have some unifying vision, and that vision isn't, let's run ^{straight} ~~short~~ for the planet we could go to. We have to think about asking some fundamental questions and seeing how we tie science and commerce together. And commerce is not a dirty word at NASA, because science, technology and commerce are absolutely integrally aligned. And some of the feedback the American public gets from the space program ^{is} ~~is~~ the improvement in the quality of life ^{giving them} ~~given~~ the technologies we ~~have undertake~~ ^{we} ~~the~~ open the space frontier and make it part of our economic system. And that will be as far away as we allow them.

So I'm here today to pose questions, tie issues together, to explore issues, set goals, and talk about how we're setting some thresholds. What I will not do today is announce a disconnected feel-good mission. And I remember on the 25th anniversary of the celebration of Apollo, there was an unbelievable pressure ~~made there~~ ^{Even more was being} ~~(inaudible)~~ "Hey Dan, ^{is} ~~is~~ NASA or the President ~~are~~ going to announce we're going to Mars?" Absolutely not. That would have been the wrong thing. Because then we'll be back ^{to} ~~from~~ where we were. We had this organic shuttle program. Now, I don't want to be demeaning to the people that worked on the shuttle, but the shuttle has suppressed a lot of science that we could be doing. There's no reason we shouldn't have been doing these things 10, 20 years ago. So we have to fight the temptation of getting an organic feel-good program that could destroy the integration of what we're trying to do.

Before I talk about this, I'd like to thank a number of people I consulted with. Harry Holloway, ^S ~~W~~ Huntress, ^{Jannet} ~~NASA~~ Sam Vaneria, ^{ES} ~~NASA~~ Jeff Placia, ^{Diane} ~~Ann~~ Ballard. I talked to Gene ^{Shoemaker} ~~Scheumacher~~ at the Galileo ^{Encounter} ~~Penetration~~, ^{France} ~~Cordova~~, ^{Carl} ~~Pilcher~~, ^{and Dr. Townes} ~~Transcordiva~~ Kolchlosa, Mike Myer, ~~(inaudible)~~. I picked everybody's brain, and I tried to synthesize some of the thoughts that people have, because no one person has ^{all the} ~~individual~~ wisdom.

What I tried to do here is list what I consider to be three fundamental, interconnected questions that we have to answer. They're multi-disciplinary questions. It's not about a spectrum or a mission, it's about answering the fundamental questions, ~~(inaudible)~~ because the American public doesn't know what a ^{Cassini} ~~keoni~~ is, but ^{they} ~~that~~ know what fundamental questions are.

First, where do galaxies, stars and planetary bodies come from? How ~~do~~ they evolve? Two, are there other places that had an environment, and in the broader sense of the word, have an environment or might have an environment hospita^ble to life and/or commerce? Three, is life of any form unique to planet earth? And I think this is what ~~(inaudible)~~ this is the fine line I was trying to get at...and that, I think, is what turns people on. So ~~this~~ ^{sketch} is not a program I'll talk about today, ~~(inaudible)~~ not a discipline, not an agency, not a specific date, but ^{any} an integrated, multi-disciplined, technological, cultural and economic quest.

We are interested in sustained presence in the solar system. We are not interested in rushing off to Mars, spending tens of billions or hundreds of billions of dollars and stopping the scientific pursuit so a few people can feel good and a couple of companies will get big contracts. That's not what we're going to do.

Now, to ~~answer (inaudible)~~ attempt to answer these questions, we could perform the following task. And again, I think this has be decided by the people in this room, scientists and engineers around the world, and I'm only proposing these as a starting point and I hope they'll stimulate discussion. First, survey space to search for and analyze the earliest formed ^{of} galaxies. Two, search for and analyze stars and planetary systems in the process of forming. Three, search for and analyze extra-solar planetary systems in our neighborhood. And our neighborhood is defined as, as far as the aided eye can see. And right now it can't see very far. It's blurry. We now are myopic. ^{Four,} ~~To~~ search for and analyze planetary bodies that were, are, or could be, habitable and/or could have resources of economic interest.

Five, Search for resources and/or signs of life including alternate life forms that we don't even know about. We just found some alternate life forms at the bottom of the ocean that don't operate the way other life forms operate, and if we can have it on our planet, by God, we could have it on others. ⁱⁿ ~~in~~ our own solar system, which we have yet to go ^{to} ~~through~~ and ~~that's~~ appropriately explore. Six, attempt to determine some of the factors controlling the origin and fate of the universe and our solar system. Everyone wants to know.

And it brings to mind a story. I went to my daughters' school when they were in elementary school, and I talked about the solar system, the sun, planets and ^{relative} ~~(inaudible)~~ planet positions, and then I made the mistake of telling these 9-year-old children, that the sun's going to burn out in five billion years. They got hysterical. ^(laughter) But these children were giving an honest emotion. Think about our own feelings as adults. So these are not insignificant questions.

And finally, and most importantly, to benefit people in America and on the planet from the richness of the findings and technologies. ~~(inaudible)~~. And you can't do this ^{with} ~~in~~ a single point program like Apollo. You can't do this with a Sprint, ^{it's a marathon} ~~that's a~~ ~~(inaudible)~~ and demands revolutionary change, not evolutionary change. Let me give you an example.

The Hubble Space Telescope. I love it. Six billion dollar life cycle. Unconscionable. ^{It weighs} ~~You waste~~ 25,000 pounds. It costs us a quarter of a billion dollars a year. ~~(inaudible)~~ It's getting great results, but at what cost? And we have to get into more of a cost/benefit analysis. So I challenge you — ~~(inaudible)~~ and I'll talk about it later ~~(inaudible)~~ ^{to the} people in this room and people across the nation ~~(inaudible)~~ ^{hyper} and I'll talk about how I think you can get ^{there} ~~this~~ without being specific. We needed ~~led~~ more than an order of magnitude reduction in weight. We needed ~~at least~~ a factor of 20 reduction in ^{cost} ~~force~~. And we needed ~~at least~~ a factor of two ^{decrease in} ~~or three to~~ ~~reduce~~ the size of that telescope. And that technology needs to be developed ^{in the next ten years} ~~(inaudible)~~. We could do it.

People out on the west coast ~~(inaudible)~~ in fact, I saw Roger Angel here. Roger tells me he can do it. ~~(inaudible)~~ He's a little too heavy, but he can get

it down a little bit. So everything is connected, and new relationships ~~is~~ ^{between} the industry and academia and government and the American people have to take place. The Apollo era is gone. America spent five percent ~~(inaudible) five percent~~ of its budget to go to the moon because we had to beat the Russians, and that was the right answer. Our budget is now nine-tenths of one percent. So I will fight anyone ~~that~~ ^{who} wants to rush forward for a feel-good mission to the moon, that doesn't have revolutionary technology. ~~(inaudible)~~ Not for the technology sake, but we need orders of magnitude of reduction in cost, ^{cost/benefit} so we get the ~~cost down~~ the ratio -- so industry could begin to think about getting involved. So 20th Century thinking is out, ^{and} 21st Century thinking is in.

* Now, if you take a look at NASA, a ~~cold~~ ^{silent} revolution happened. ~~(inaudible)~~ I think we could go, and I don't think anyone would notice it. ~~(inaudible)~~ NASA is no longer an object-oriented program. We no longer have a ^{Physics} ~~Space~~ Division to serve the space physics people in the university system. We no longer have a planetary division that has a community that needs so many hundred million dollars a year. We no longer have an astro-physics division. We have intellectual leadership at headquarters based upon questions that need to be answered, and multiple disciplines. We no longer organize ourselves around wavelengths. We no longer feel constituent-oriented, the people who go to the Congress and have to have a specific level of budget so that they don't have to lay people off.

^{to appear heartless.} Now, I don't want ~~a peer office~~. We've got to be dominated by work that's outstanding, and the work cannot be subsidized by the American people ~~that~~ ^{to} provide stability in laboratories. Your work's got to make it through free-flowing peer review research, and not ~~(inaudible)~~ ^{perk} from the Congress. And this has hurt the NASA program. Nobody's bad, but sit in my office sometime and you'd throw up from the calls you get from the Hill. ~~(inaudible)~~ Good people on the Hill, because people are trying to maintain the status quo, and ^{the NASA team} ~~(inaudible)~~ is bound together and determined, never again.

So, we have a shared vision. We're going to look at the planetary system, not as planets in our solar system. We're going to look at ~~our~~ ^{the} planetary system as every possible planet that we can see with the aided eye. And

- truth

comparative

we intend to do ~~relative~~ planetology. We intend to get ground ~~crews~~ from what we can see with robots in our solar system ~~(inaudible)~~ ^{with} what we can see, where appropriate, ~~the~~ ^{with} people ^{who} ~~that~~ walk on planets in our solar system, or we can see remotely in nearby suns.

So what we have done is, we have taken the program responsibility away from NASA Headquarters. It's gone, it's finished, it's done. We've actually ~~trust the people in the Field Centers~~ ^(inaudible) ~~from the field sensors~~, We've identified ^{lead} ~~new~~ Field sensor's Centers functions, and we're out of command and control. ~~No more people control~~ ^(inaudible) ~~No longer will people control the holds that NASA had at~~ Headquarters, looking for hot dog stands. We're shutting down every scientific hot dog stand, and everything must be related to the strategic plan for NASA, and everything must be related to answering basic questions.

And we're open. We want the scientific community to come back at us and say, "Hey, we don't think the questions should be this way, they might be that way." But we're communicating with the American public, ~~(inaudible)~~ ^{we're} online on the Internet—we get an unbelievable amount of hits—and we want to work together. We've got to close all these hot dog stands because as our budget comes down, it's not allowing us the kinds of research that need to be done. So for our part, Headquarters will no longer be measured in multiple thousands of people, it's going to be measured in ^{hundreds of people} ~~the methods~~ ~~that people use~~. Good people are going to go to the Centers, and good people may no longer be with the Agency.

I don't want you to feel there are bad people, but this is a fundamental change in the seascape. Headquarters will determine the what and why, Centers will determine the how. We will not usurp the responsibility of the ^{lead center} ~~(inaudible)~~ and directors. Engineering is going to be short-cycle time. ~~(inaudible)~~ As a general principle by exception, we won't start programs beyond three years from the start to launch, unless there's some real compelling reason. We'll demand that all the technology get done in advance. You could have experimental ^{programs,} ~~floor plans,~~ you could crash ~~fly~~ ^{from the point} ~~ones~~ you start ^{to the point of finish} ~~with~~ ^{you} finish, unless there's some rule of physics that says ^{we'll} ~~have to~~, three years. start new things every year, and that's how ^{we'll} ~~to~~ do it. We will have a

{ Low cost; each mission has to be less money than the next.
Because our budget's coming down, and it's not even getting corrected for inflation, and we want to

technology pipeline. In the past, every program had to have their own technology, and now we're setting up the technology pipeline for launch, setting up the technologies pipeline for spacecraft, and we're not going to fund technology on a hot-dog stand basis. ^{It will} They all be covered (inaudible) based on (inaudible).

And it brings to mind a question a young engineer asked me, ^{I was in the} ~~that was at a~~ job, maybe about three or four days. And this young engineer said to me, "Mr. Goldin, I have a problem. I found a new device that no one will fly. I go to the program managers and they say, has it flown before? And he says no, so they say to me with a pat on the head and the back, go away young fella. Go get it, ^{flown} ~~tested~~ and then I'll fly it." You know, how is a Catch-22? Well, we are now ^{setting} ~~sending~~ up a series of spacecraft that are going to be technology directed, so we can test these new technologies out so when we go into the missions, we don't have to have risks.

This is the concept and, I'll tell you, I've got to thank one person in this room here, Jerry ^{Pournelle.} ~~Fennell~~ ^{He came to me} ~~Banyon~~. Early in my tenure he talked to me about this experimental concept and a number of others. Really competitive things, and I probably (inaudible). So we now have the tools, we now have the approach, and now we have the planetary approach that's ~~we've~~ broadened ~~up~~ out.

So how do we go at it? I propose that you consider that there be four phases to planetary exploration. I'll call Phase 1 ~~Robotic~~ **Robotic** precursors. This is where you can throw flyby, orbiters, landers, rovers, sample-return devices, to kind of scout the land. To find the places that have some real potential. Phase two would be **Initial Human Exploration**. That first few flights, (inaudible) You don't have to plan it for a whole long series. Just the first few flights.

Then as you get more data ~~in the, you know~~, the cost benefit ration starts getting better, the potential for scientific resources or commercial resources appears, and as the cost goes down that ratio is really sharp. You then go to ~~(inaudible) in the~~ ^{Robust Human} **Exploration**. And then finally, you go over the threshold, to phase four, **Sustained Human Presence**. ~~And~~ I think we need to think about these different thresholds because we mix our

metaphors. When we talk about missions - ~~(inaudible)~~ "Key, I want to go to Mars." - ~~Well~~, what ~~the~~ people generally say is, give me the price for that first flight. And that's unfair to the President and that's unfair to the Congress and that's unfair to the American people. And these phases have a hierarchy. It's a resolution of spatial, temporal, spectral, analytical, and adaptability to tools.

Let's take a look at them. The lowest spatial resolution, the lowest ~~spectral~~ ~~specialized~~ resolution is going to be ~~the~~ ^{from} telescopes on the ground. We've done it for centuries. And the first big leap is to take the telescopes off the ground and ~~to~~ put them into space, ~~then~~ ^{and} get rid of ~~your~~ ^{the Earth's atmosphere.} ~~adapters.~~ Ultimately, the telescope's going to have to leave earth's orbit. We're going to have to put the telescope out at about 5 au, so we get rid of ~~the~~ ^{zodiacal} light, if we ever want to look at planetary systems around nearby stars.

And then you get better resolution by going through a fly ^{by} ~~(inaudible)~~ and that's what we did with Mariner II to Venus. And it opened up our eyes. Then we orbited the moon, the lunar orbiter in the Mariner series. And then we landed the Surveyor and Viking. I mean, that was it. We haven't landed on a planet for 20 years now because we've been so excited about the service ^{support} ~~award~~ contracts on the shuttle that we're not doing science. We spend \$10 Billion on the space station and didn't produce ~~a~~ a piece of hardware, but boy, did the contractors have fun.

It is shameful; ^{it's} ~~that~~ stealing from the American public, ~~(inaudible)~~ and these are good people, ~~(inaudible)~~ but we have a bad system and we've got to wipe out this bad system. And we're getting there. We've made tremendous progress. And then after we land in fixed positions, we've got to roll. We're not going to wait two more decades to roll. Within days of the ^{time} ~~find~~ that the Mars Orbiter was lost, we started the Mars Pathfinder. At one-quarter the cost, we're going to land a Rover on that planet that could move ~~out~~ ^{from Earth.} around without command ^(i.e.) ~~(inaudible)~~. We say, go from here to there, it will figure out where the rocks are and will go around the rocks. It has its own eyes and it has ~~(inaudible)~~. I don't want to say a brain, but it has a reasoning capability, and that whole rover may have cost \$10 Million. Maybe 15. It didn't cost a good fraction of a Billion dollars. And they're building the whole thing in three years, and if they launch it ~~for to~~

Mars and it doesn't work, I'm going to hug that team for having the courage to do it, because ~~they~~^I want people to take risks. Spacecraft are less expensive, and we could afford failure because we've got to push the technology in these areas.

And then after we rove we bring back samples, or we can put an instant new lab ~~on~~^{out} there like we had the Viking biology ~~lab~~^{life detection experiments} protection. That trade isn't very clear to me. I think it will probably make sense to bring the samples back so we don't have to miniaturize a chemical and physical lab (inaudible). So Stardust is our first sample return, and we don't have to wait until the middle of the first decade in the next Century to do it. And then clearly, you've got to put people on the surface when we find out that we exceed the threshold of the cost/benefit ratio.

Apollo was enabled by the technology of Saturn and the ~~numerous~~^{Lunar Excursion Module} (inaudible). Jack Schmidt found active ~~(inaudible)~~^{volcanism. There because he saw orange glass.} Now people say to me, "~~then~~^{Dan} why don't we send rovers? Why don't we sent robots to do this work?" To which I respond, the minute you show me a robot that roves the earth doing (inaudible) geophysics, ~~at~~^{is} the very moment I'll send a robot, at ~~you know~~ 10,000 times the price, and put it up on a planet. It doesn't have cognitive ability yet, it doesn't have versatility yet, it doesn't have manual dexterity yet, and it doesn't have adaptability yet. Now, maybe when some of these robots come into being, we won't need people for that aspect, but we still need the cultural aspect. And people are going to inhabit other planets at some time, I don't know when, and it won't just be robots, it won't just be ~~(inaudible)~~^{robots}.

So the challenge is to figure out what are these cost/benefit thresholds between Phase I and Phase II, Phase II and Phase III, Phase III and Phase IV. And it could be scientific, it could be economic, and it could be cultural. And I say, we ~~should~~^{do} not ignore it. I'm not saying overplay it, I (didn't say) (inaudible) ~~over~~do it for money, but if there's a commercial benefit or scientific benefit, people of the United States or people around the world are going to pick up the bill, and ~~you~~^{we} we've got to factor in communications that do not put science into a black hole.

And I want to tell you, we've made very little progress since I begged this

organization a year ago, to get the scientists to start communicating with the American people. We haven't made progress. I've probably been in 20 or 30 cities since I gave that speech and people are still saying to me, I'm not seeing ^{it} ~~(inaudible)~~. You need to do better, I need to do better, we need to do better.

Now, let's take a look at some of these scientific benefits. And again, you can make your own list, but I've made mine and I'm speaking ^{about it so you can} ~~(inaudible)~~ decide whether you like it or not. First, and probably one of the most compelling, are there present or past forms of life at any level. If we could find a fossilized, singular-cell life, it would change a lot about how we think of ourselves. How is the planet structured and how did it evolve and what are the implications to the earth's evolution or general theory of evolution of the earth? Can we unravel the body's climatic history and environmental history so we can better ^{understand} our model for the climatic understanding, because when you start doing climatic experiments you need a laboratory the size of a planet. You can't get some of these ^{parameters inside of a laboratory.} ~~(inaudible)~~ performance ^{of planets} ~~(inaudible)~~.

From an economic standpoint, the most compelling issue is, can you find resources to live off the land? And in fact, if you ever want to get to Phase II from Phase I, you must have that, because it's going to be too expensive. As Bob Zubrin points out, the load-down of spacecraft with all the breathing ^{gases} ~~gears~~, all the fuel to go there, to stay there and come back. So I would say it is my intuitive feeling that you almost have to say finding resources to live off the land has to be a condition to go from Phase I to Phase II.

Second point on the economy is, are there natural resources, in the broadest sense, of economic value? Are they ^{re} environmental ^{al} conditions conducive to manufacture of high value products, because ^{of the} ~~(inaudible)~~ environment that you have there ^{that} gives you unique ^{ability} ~~cost and~~ performance better than what we have on earth. And there are a whole variety of parameters ~~(inaudible)~~. And maybe, just maybe, ~~(inaudible)~~ Tom Rogers, ~~have~~ ~~(inaudible)~~ reality.

Now, when you think about geological fieldwork, and you look at this

article in Time Magazine, you know, the geologists made ~~(inaudible)~~ the paleontologists made a trade. They took a look at Landsat pictures... perhaps ~~(inaudible)~~ I didn't get into their brain... ~~(inaudible)~~ they took a look at other things, and they saw there's some places in Australia that offered some promise. Did they send a robot to Australia? No, it was a cost/benefit to get a plane ticket and rent a car to go to the site themselves. And they went to this. In other cases it made more sense to send a robot, so when they went to the bottom of the ocean to make some of those measurements, they sent a robot.

And this is okay. You don't have to have robots and you don't have to have people. But you do this horse trade so that it makes sense, and then you proceed forward instead of making macho statements saying, "I'm going to go, follow me." That's what happened with ~~SETI~~ ~~efforts like (inaudible)~~ President Bush genuinely believed this was the right thing to do and to me, NASA let him down. We led him down the garden path because we didn't tell him how much. How much was a quarter to a half trillion dollars measured over 30 years? You know, it dims the light on the gross domestic product. ~~(inaudible)~~. This is not the way to do space science. So we need to really think through this cost/benefit analysis.

Now, let me define what I mean by the life zone, because I know there are those who say the only place to go is Mars. It may be the only place to go, but if you think about ~~that~~ ^{what} the definition of the life zone is in the broader sense, I think we may open up our minds. The life zone is not the range of distances between the sun, where conventional thought says that water will be stable... ~~And we, you know,~~ ^{where} it won't boil ^{and} it won't ^{freeze} grease. It's much more encompassing. It's a multidimensional space of temperature, pressure, composition and time, in which conditions necessary for life could, does or did, occur. Very important to think about that.

So the robots have begun to explore what that life zone is in our solar system, and they'll define the life ^{zone...} ~~(inaudible)~~ they've begun to define ^{the} a life zone in another solar system. ~~(inaudible)~~. The earth, we can go down to Antarctica. ~~(inaudible)~~ Chris McKay is here, he's done that. It helped us to figure out where to go on the Viking, except the data came two months after we launched it, so we went to the wrong place to search for life. You

know, we look at the deep oceans and we see other characteristics and we look at Australia. Now, Mars looks like a place that might be right, and we all know...~~(inaudible)~~ most of us know the arguments about Mars:
~~(inaudible)~~ it might enough water, comets and asteroids could have landed there with the building-blocks of life, there are dry lake beds. There are all the conditions conducive that life could have or might exist.

And we're going to begin to get a sense about that. But we have to look at complex environments - ~~to~~ ^{at the} ~~the~~ ^{interplay} with geological processes, chemical processes, physical processes, biological processes, and a whole host of transport processes. And these are the things that produce the conditions we can't always predict or imagine.

One.

Now, let me pick a wild and crazy ~~(inaudible)~~ In the summer of this year we fly by ~~Europa~~. First blush from Voyager says, ~~ah~~ it had these cracks that come and go. Maybe the ice is healing itself. And then when you take a look at it, the gravitational pull could be putting enough energy into the core of this body that we might have an energy ~~source~~ ^{source}. And then if you look at the density, looks just like a ~~chondritic meteorite~~ ^{chondritic meteorite}. And that has building blocks of life. So if you look down to the earth's ocean's floor, in the deepest channels on earth, maybe we might find the kind of life there that might be on ~~Europa~~ ^{Europa}. Who knows? I don't know. run on

But I certainly keep an open mind and when we think about where we're going to go next, I have deep respect for what I don't know about. But who knows, it might have a 10-kilometer ~~thick~~ ice crust, on a 100-kilometer ~~deep~~ ocean. Who knows? # Venus, maybe billions of years ago, could have been in the life zone. Today it's not. # ^{→ The Moon.} ~~Venus~~ ^{Venus}. What if the Lunar Prospect finds ice ~~(inaudible)~~ ^{at} South Pole. Who knows? I want to tell you, there's going to be one beeline for the moon. All sort of possibilities. Maybe Titan ~~(inaudible)~~ ^{Cassini} once it's there in '97. And as Gene ~~Schoemaker~~ ^{Schoemaker} points out, water ~~(inaudible)~~ ^{abounds on the near-Earth} on the earth's asteroids. There could be a wealth of possibilities in those asteroids.

And then, not only do we have the possibility of life, but we have the possibility for some ground ~~crews~~ ^{truth}. Think about ~~Europa~~ ^{Europa}, and think about the moons that might exist around these planets that we just have found.

What if we get some ground ^{truth} ~~crews~~? We have to understand life here and be open and imaginative. Let me just give you one little speculation. Let's say we find an earth-sized, blue-green planet. You say ah, we found life. What if we found a blue-purple planet? Should we stop? Maybe we've got photosynthesis from rhodopsin, and maybe life might be the same, except it's rhodopsin instead of chlorophyll. So we have to keep open minds.

So the possibilities are great but there are limits to what we can do. The ~~NASA~~ ^{NASA} ~~National~~ budget's coming down, and before we can even think of stepping foot off this planet, we have got to fix, the festering, nagging, shameful problem that we have in this country ^{in launch vehicles.} ~~(inaudible)~~. I'm embarrassed, I am part of the problem. I feel we have not served our country well, yet every time we go forward with a new launch vehicle, the scientists are worried about their programs. ^{I'm here to tell you,} ~~If you tell your~~ scientists, that unless we have a launch vehicle there will be no science, ^{we} ~~that~~ can no longer afford \$10,000 to \$20,000 a pound.

And I testified under oath before the Congress that the highest priority for ^{a new} ~~them to~~ start at NASA, was to fix this and go on to a different problem.

Even if the budget comes down, we will cancel programs. Never again are we going to pay the price we paid, ^{for redoing} ~~in renewing~~ old ballistic missiles that my company ^{system} ~~engineered~~ in the fifties. I'm embarrassed for our country. Good people have been living with the status quo, and if this doesn't change, we can talk all we want about space, we can talk all we want about ^{interferometry} ~~(inaudible)~~, we can talk all we want about instrumentation, ^{but, most} ~~because~~ we have ^{new launch vehicles.} ~~(inaudible)~~. And it's not going to happen with an organic program. Let's throw \$10 Billion ^{at} ~~in~~ it. ^{Design} ~~So~~ ~~(inaudible)~~ a little, build a little, test a little. I'm going to keep the program a small ⁱⁿ ~~size~~ so no one will get rich immediately. The place to get rich is after you figure out how to do it ^{for} ~~in~~ an order of magnitude of less money. ^{After you get into that shuttle,} ~~After~~ ^{they can do is} ~~(inaudible)~~ bail out. ^{for the astronauts} ~~after~~ two minutes there's nothing we can do. All ~~(inaudible)~~ ~~the astronauts~~.

But we've got to be honest with the American public and not deceive the American public that they're getting something that they're not getting. They can no longer afford billions of dollars a year with tens of thousands of people hugging the shuttle. There are some people who think the

start new
TAPE
GAP

~~still successful~~
~~two minutes~~
~~the astronauts~~

shuttle is the ends, not the means of the program at NASA. Now, it's a wonderful machine and we're going to make that machine as safe as humanly possible. In fact, the reliability on ^{ascent in} ~~NASA end on~~ the last three years has (inaudible) because we invested money to make it that way so the astronauts would have more confidence getting in.

But there are those who think they're going to keep the shuttle program alive to the year 2025, and I want to tell you, they're whistling Dixie. Unfortunately, this crew is in agreement. Come to an AIAA meeting and you'll see ^{The Crews.} (inaudible). I mean, we are taking money from science and putting it into bureaucracy. Where is it said you need 20,000 people to build a launch vehicle? But given that fact, I'm proud that we have a safer vehicle ^{with} ~~that~~ a million dollars (inaudible). ^{of new investment} This money helps fuel (inaudible). So that's the first item on my list, and probably the second, third, fourth, fifth and sixth. That's the only way we'll leave this planet. That's the only way we can do a mission like ^{Gene Shoemaker proposes.} (inaudible).

Then we have to, second, figure out how people could live more safely and efficiently and productively in space. You can't ^{take} ~~point~~ people in a 1-g environment and throw them into cosmic solar radiation, zero gravity, and say have a nice day. There are fundamentals of life science that have to be undertaken, and this is where we as an Agency, must nod to the medical science, life science, biotech (inaudible) all the ^{communities} ~~computers~~ in this country. NASA will no longer be about rocket boosters when we fix that trouble.

NASA's going to be about life sciences, about how to ^{medically} ~~hermetically~~ select and protect ^{flares,} ~~cosmic~~ (inaudible) cosmic, solar, (inaudible), (inaudible), radiation, life support.

How do you control microbial elements for two, three years. — It's a very small environment, — without getting a Legionnaire's disease. But if you get Legionnaire's disease, what do you do? How do you make a personal life support system? A space suit ^{that doesn't} ~~(inaudible)~~ it cost \$10 Million. It costs ~~you~~ ^{know} a good fraction of a million dollars every time you use it. The object of the EVA suit is not to make people wealthy or give them jobs. The object is to protect the vehicle activity.

Microgravity affects the heart, the muscles, the bones, the immune system, the nervous system. By studying how to get countermeasures to them, we'll better understand human physiology so we can enhance the quality

of life on the earth. We need new concepts in medical care. You know, on Apollo we invented intensive care monitoring, and some of the people in this room have had to have these little battery packs you carry around. Just about this big, looks like a transistor radio. We intend to put that on a microchip that you can't even see, using nano-technology. And in fact, right now some of this technology is being used at the University of San Francisco to put implants into children that are still in their mother's womb so you can monitor their vital signs ^{and perform surgery.} (inaudible). So it's not in the future. It's here. Chemical surgery, select and induce resistance to illness. ^{Tele} ^{to enhance diagnosis.} ^{Cal} ^{medical Support} ^(inaudible) These are going to be done in the space station and ground support.

This is science, this is important science. We have to figure out to make robots and how to integrate them with humans. We are on a path to develop robots that think, see, hear, touch, smell, speak, talk, perform mechanical operations. Right now we robotics assistants. By the time we get done with the space station we intend to have robotic ^{re ing them} surrogates (inaudible). And we'll go ^{into testing} in space. When we put the astronauts in space they're not going to do into space with ^a 400-pound space suits and at least 10,000 hours of ^{pre-breathe} (inaudible).

Third, we need tools to produce higher resolution spatial, spectral, chemical, and life cycle ^{to cut costs} of course, science space-based ^{infrastructure} stations. And here is the concern. Let me use the Hubble ^{space} telescope as an example. Hubble is as safe as every other telescope we've put in space. Because we've built telescopes ^{on the ground with} (inaudible) ^{we take} huge pieces of heavy glass, We said uh-huh, when we build a space ^{based} (inaudible) telescope we'll do the same thing. And then ^{on the ground, because of gravity, we need an ultra-stiff structure. I mean, sort of I-beams for a metering truss.} ^{short of} (inaudible). So we made this thing so darned stiff that you don't have to worry about any problem.

So then what we do is, we take the same technology and we try to put it on a launch vehicle. And so we get a \$6 Billion, 25,000 pound wonderful Hubble ^{telescope}. What we need to think about, and will open our mind, is instead of rigid trusses, get the rigidity ^{with laser beams.} (inaudible). Use floppy structures and go to adaptive structures to correct dynamic problems and cause these static problems. Control the surface of the optics so you don't even have to

test it on the ground, and figure out how you take this ^{floppy thing, 1r} ~~(inaudible)~~ thin, put it into space, deploy it, have it ^{adaptive} ~~(inaudible)~~ control. Now, I'm not talking about tomorrow, but we've got to leave our old ways if we ever expect to get a factor of 20 to 30 reduction in cost ~~(inaudible)~~.

Now, I want to tell you, I just read a ski magazine. K-2 Ski's has the following ski ~~(inaudible)~~ which I will buy next week when I go skiing in California. It has a ski with a ^{piezo-} ~~piezo-~~electric device, so when you go over bumps you build up a charge on a capacitor which then gets dissipated, ^{and} the ^{result is} ~~resistant~~ of the skis don't vibrate. Now, if K-2 can build a ski to do that for a few hundred dollars, we ought to be able to build an optic twice the size of the Hubbel Space Telescope. An adaptive optic. We ought to be able to make that one-tenth to one-thirtieth the weight, and one-tenth to one-thirtieth ~~the weight and one-tenth to one-thirtieth~~ the cost, and all of a sudden we could see anything we want to see. Maybe ^{out to} ~~(inaudible)~~ ^{light years.} This is important stuff. And then, instead of grinding things, we ought to replicate ^{surfaces, services,} and instead of grinding and polish, we ought to think focus. It's a whole new way of thinking, that you can apply this active control of ~~a~~ large space ^{structures} ~~(inaudible)~~. And they're building systems in space with zero G precautions.

Now, the first task that I talked about, the lead center, ^{is} ~~this~~ NASA ^{Marshall.} ~~module~~ I told them, shut the hot dog stands down, and all you've got to do is work within this ^{framework} ~~(inaudible)~~ academia ~~(inaudible)~~. NASA Johnson's been worried about operating a space station and figuring out how people can live and work in space. ^{JPL} ~~Jay Piel~~ worked with academia and industry, ^{and} resolved this problem.

The fourth problem is probably the most difficult, and not necessarily the least priority. There's revolutionary change in design, simulation, and analytical tools. We're in the dark ages because of tools, and I ask you to think about this. We have ^{inhomogeneous, non-isotropic materials,} ~~\$9 Million in (inaudible)~~. If you fail a composite it doesn't yield, it explodes. We have complex environmental inputs, we have stochastic processes and non-deterministic systems. Now you mix all this stuff together in a ball and say, where's my design ^{tool} ~~crew~~? It's non-existent.

First of all, if we're going to work with composites in some of these ~~master~~ ^{materials} (inaudible), we need a physics-based design ~~tool~~ ^{tool} to start with the individual molecules and the forces between them. It builds up (inaudible) design (inaudible), and started (inaudible). But this is the type of thing we would hope we have ~~(inaudible)~~ ^{partnership...} this is a perfect job for academia. This is the kind of thing that needs to be done. We have these designs ~~but~~ ^{tools...} we design ~~in~~ ⁱⁿ black plastic, do you know what I mean here? Black aluminum, design ~~in~~ ⁱⁿ black aluminum, you know, when you take composites and you do safety factors like you ~~do~~ ^{do} in the ~~(inaudible)~~ aluminum. But it's non-elastic. It's not isotropic. It doesn't make any sense. Beechcraft tried that with that ~~Starship~~ ^{Starship}, that's why it failed. They designed in black aluminum. The University community needs to work with us to build these physics-based ~~(inaudible)~~ ^{tools.}

Then when you think about what has to be done when you get adaptive, intelligent, learning, self-generating, software to deal with the chaos and the sheer magnitude involved in (inaudible). And then we need computers to go along with that. And may ~~in the (inaudible) of things we went~~ ^{be limit we go to wet computers.} (inaudible). Genetic-based algorithms could provide stable, state change of complex systems, and we are working on this. The other problem is, travel is too expensive. People get on planes, still today, because we don't have geographically distributed user-friendly tools to allow collaboration. So we need interconnectivity, interoperability, ~~(inaudible)~~ ^{wide bandwidth,} with common media and low cost.

We have just changed the mission of NASA Ames. I ~~called them~~ ^{told them,} stop hugging ~~with the (inaudible)~~ ^{wind tunnels}. Let go. Let's take the science mission at NASA Ames, and turn it into an institute, and let's focus NASA Ames, that's right in the center of the information capital of the world, into the center of excellence of information and technology in the world, so we can develop these tools. And we're starting ^{we're working} with the entire industry, we intend to have a virtual laboratory for developing ~~the~~ multimedia tools. Right now ~~the duties (inaudible)~~ ^{for doing these kinds of tasks.}

So these are the type of things. ~~(inaudible)~~ ^{ing} Now, anyone can make their own list, but I think these things go to the heart of the problem, and these issues get back to scientific fundamentals, started ^{ing} at the beginning with

1r 23

the molecules. So I'm ^{highly} ~~finally~~ confident that we'll be able to do all the things that one can name in one vision.

Let me ask you to think about this. A few decades from now a young lady, who is the daughter of this Bell Atlantic technician, ^{will be the director of JPL.} (inaudible) And she's going to be sitting in her office and she'll be looking at a number of images in this picture-framed video display on the wall. And she'll be looking at direct ^{detection} ~~action~~ and analysis of ^{some} ~~certain~~ planets, and she will have seen a planet, and if we didn't have enough resolution to see ocean ^{and} continents and clouds, but because the planet was spinning we had a few pixels, she was able to ^{discern} ~~observe~~ some ice caps, she was able to ^{discern} ~~observe~~ some ^{temperature} ~~some~~ (inaudible) variations and ^{typical galactic} ~~typical~~ characteristics. (inaudible).

And she also took the data in an office ^{where the} ~~when a~~ mission that she helped lead, before she got that job, to land the first U.S. ^{human on Mars} ~~(inaudible)~~, and the first demonstration phase of the mission. So perhaps, just perhaps, something would happen. She was waiting, the phone rang, and ^{the} NASA Administration ^{Turn on your screen. I've} ~~called~~ and said, don't come to Washington, ^{free.} ~~They've~~ got to show you something. Perhaps they and the rest of the world see something that changes history. Something that changes what it means to be a human being, and perhaps, just perhaps, they would see something that suddenly ^{and} forever changes. ^{everything} Thank you very much.

(Q & A session with audience)

Q. (inaudible)

I have not spoken to him.

Q. (inaudible)

I understand. I mean, I try and talk to as many people as I can. I'll be happy to talk to him.

Q. (inaudible)

I understand, and, I will do that. I will take it down, and if you give me a card, I'll tell you what he said.

Q. (inaudible)

What's that?

(inaudible)

Oh, Time Magazine (inaudible) my eyes are old eyes (inaudible) it looks like December 4th, '95. ¹⁹⁹¹ ~~(inaudible)~~ has good eyes.

December 4th, ^{if} ~~It~~ had ~~(inaudible)~~ right. Yes sir?

Q. That's an inspiring vision you sketch, but you're not going to ~~(inaudible)~~ the space station ~~in particular~~ ~~(inaudible)~~ could you expand on that for a bit, please?

Well, I appreciate your comment, and let me respond to it. The space station is being built to see how people can live and work safely and efficiently in space. Now, if you want to test someone at zero gravity, you can try to do it on the earth and you get 28 seconds ^{if they go in a} ~~(inaudible)~~ ballistic parabola. ~~(inaudible)~~. If you want to expose someone to years of zero gravity and get real ~~(inaudible)~~, real sophisticated ~~and~~ medical ^{devices} ~~(inaudible)~~, the only way we know how to do it is to go into an orbit ^{that keeps falling.} ~~(inaudible)~~. And we know ~~in~~ an orbit we ^{can} keep ~~(inaudible)~~ by going ~~(inaudible)~~ ^{into} orbit around the planet earth. If we want to go test robots in zero gravity, we don't know how to do that and have those robots ^{interact with human beings for} ~~(inaudible)~~ ~~direct~~ ~~(inaudible)~~ 29 seconds.

There are a whole host of issues. If we want to really test how to ^{contain} ~~obtain~~ samples and bring them back to earth ~~(inaudible)~~ because if we bring back specimens ~~(inaudible)~~ there are a whole ^{host of} ~~(inaudible)~~ microbial ~~(inaudible)~~. You can make long, long lists, so, sometimes people ^{think about, oh, the} justification for the space station is to do microgravity ^{and life sciences.} ~~of myself.~~ The justification of the space station is to figure out how people can live and work safely and efficiently in space.

That's something we have to do, and then because we set up this unique facility, ~~(inaudible)~~ we have 100 kilowatts of electricity, we have a pressurized volume equal to the size of two jumbo jetliners, we have 14 of the most developed countries of the world participating, we have six researchers on board, probably one and a half will be tied up with maintenance. We can do stunning science, I want to tell you. Even in that domain, even though ^{that isn't the justification,} we are getting stunning results. Biotech ^{to materials} ~~(inaudible)~~. Testing Nobel prize theories. The theory of ^{phase change} ~~space~~ ~~(inaudible)~~. So it is there.

Now, the point I want to make is, the reason the space station got into trouble in the first place and we kept debating it, it is no longer a debatable issue. We are going to build the space station. That's why we

spent \$10 Million in 10 years and got nothing, because NASA tried to please the Congress. A responsible parent sometimes says, "no". We're saying "no" to redesign, we're saying "no" to changes, and we're going to build a space station. We are less than two years away from launch. Now, we set that schedule in October '93. And unless there's some act of God we can't control, we're (inaudible).

We have a reserve, (inaudible), and the other thing we did that's unique is to set aside \$2.6 Billion reserve for science. Engineers cannot touch one nickel of that science. The problem we had is we had a solution seeking a problem. We now have a problem seeking a solution.

And the other thing I want to tell you (inaudible) and this gets back to a point that was made with Gene ^{Shoemaker} ~~Scheumacher~~ in a press conference, (inaudible) someone said, Gene has an idea ^{for a mission to an asteroid, will you approve it,} that (inaudible) ask (inaudible) approval. I got a little cute and said "no". What I really wanted to say was, we have these thresholds to go through, and if Gene can make it through the process, and it will be a peer review process (inaudible) it will be a national peer review (inaudible) if he makes it through, and this is the priority in (inaudible) mind. Now, his argument is, it's less expensive to go to an asteroid than it is to go to the moon because there's almost no gravity on the asteroid and you don't need delta-V going down and going up. And he says the scientific riches on the asteroid has great possibilities.

Now, one of the things I didn't talk about was, we would like to have some demonstration missions ^{Instead of just pausing between} and just causing (inaudible) Phase I and Phase II. ^{low cost} It's a ^{Real quick} (inaudible) force mission to prove out the technology and ^{safety savings} And one of the things I did was, I challenged the folks down at NASA Houston. I said, it cost \$11 Billion on a current basis ^{in FY94 dollars to go} and \$94,000 ^{to the Moon} (inaudible) on Apollo. I give you the following ^{Gedanken} (inaudible) experiment. Go to the Moon, (inaudible) you're getting no money to do this ^{study...} stuff (inaudible) figure out how to go to the moon, land two people on the moon, keep them there for three days, bring them there and back safely, no other requirements. And then I said, figure out how to do something similar for an asteroid but, number one, something in the range ^{of a} factor of thirty ^{less than} (inaudible) Apollo (inaudible) ^{on a recurring} basis.

They weren't afraid. And right now, we'll see how they go. I wouldn't want to. ~~(inaudible)~~ I don't want to usurp what they're going to say a year from now. And I said, no outside contractors, you can't have thousands of people. I want you to sit in a room, I want NASA to start getting technical instead of being contract managers. And then we'll ask contractors to do this later. But I want to re-establish ^{the pride and excellence of} ~~and try (inaudible) next (inaudible)~~ NASA. They told me that we could go ~~(inaudible)~~ and I had fun doing this also ~~(inaudible)~~ Apollo was 136 tons in their calculations ^{and they could go for 26 tons.} ~~(inaudible)~~. Very different.

But you know what they said? The thing that's killing ^{there is launch services.} ~~(inaudible)~~. And that's why when Gene ~~(inaudible)~~ someone said, well, will his asteroid mission go, the sooner we get margin of control I feel will get ~~(inaudible)~~ asteroid. He may ~~(inaudible)~~ that may be the very first mission we're going to perform, and that's administrative ~~(inaudible)~~ technicians, I tried to. Thank you very much.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Friday, February 9, 1996
Baltimore, Maryland

Transcript of a lecture given by Mr. Goldin at AAAS
in Baltimore, Maryland, on February 9, 1996.

P R O C E E D I N G S

MR. GOLDIN: It's really a privilege to be here. I spoke at the gathering last year in Atlanta, Georgia. I talked about the author's task of communicating numerically. The criticality of the scientific community not looking into itself would recognize that the American public is picking up the bill for all the science that we do, and sometimes in the joy and passing what we would get, that the ultimate consumer of science and technology that we're working on for the American public.

And I have a little story about the American public -- it's got to be lowered. And this story takes place in November of last year. My wife and I had just moved into a house up on Capitol Hill and I was trying to get the phones hooked up. I got the phone line hooked up but I couldn't get the fax line hooked up and I was feeling kind of naked at the time without my fax at home. So we arranged for a technician from Bell Atlantic to show up at our house at 9 o'clock on Thursday morning, which was I think, the week before Thanksgiving. And it was clear why I would be there at 9 o'clock, was I was non-essential to the Government had shut down. So my wife went off to work and made sure I took care of all the chores in the house.

So that was the -- it was also an interesting day because at 11:10 that day I was going to communicate with the

1 International Crew on Board the MIR, from my house. And I
2 had refused to go into NASA Headquarters because we were on
3 furlough and I felt it inappropriate that the Administrator
4 bring in the crew in the TV studio so I could talk to them,
5 so I just asked Mission Control, can I make this call from my
6 house? And they said, sure.

7 So 9 o'clock passes, 9:30, 10 o'clock, 10:30. A
8 few minutes to 11 the doorbell rings and there's this big,
9 tall guy at the door and he can hardly speak English and he
10 says, "Hi, I'm from Bell Atlantic. I'm here to put in your
11 fax line." I said "I know, but I've got something important
12 to do." So he says, "I can handle it real quick, don't
13 worry." So I opened the door, he goes dashing into the room,
14 he says, where's the plug for the fax line? And in our
15 kitchen we have two plugs, one for the phone line which was
16 alive, and one for the fax line which was dead. So he imme-
17 diately injects his tool into the fax line and Mission
18 Control's calling me and they hear, whoo, whoo, whoo --. So
19 I said, "could you pull it out, please?" He says, "not to
20 worry. You've got a few minutes before the phone call." I
21 said "this is a very important call."

22 So finally he pulls it out. It's now five or six
23 minutes after 11 and Laurie Bader, who's the head of Public
24 Affairs, came to my house so she could -- just to see what
25 was going on. And by this point in time the tears are just

1 falling down my cheeks, it's so funny. And I didn't want to
2 tell him because I felt he wouldn't believe it. So, he says,
3 "I'll tell you what. If you don't want me to work in the
4 house I'll go to the switchboard outside" -- and I said,
5 "please don't." So it's now 9 minutes after 11, we're all
6 getting kind of nervous, so I said, "here look, why don't you
7 sit on this couch next to Laurie?" And I turned on the TV
8 and there are the astronauts floating around in all different
9 flags, and he still doesn't get it.

10 So I said, "I'm going to talk to space." He rolls
11 his eyes. And then he hears my voice coming through the TV.
12 The guy about died. And it was really an historic event
13 because we sent the shuttle up to a Russian space station, we
14 had a Russian on board, a German on board, we had a Canadian
15 on board, and the Americans. I mean, this was almost a
16 representation of all the people above the space station.
17 The only people that weren't represented were the Finns. I
18 mean, it was really an historic mission.

19 And I was still -- I mean, I was still more wrapped
20 up in the mission. I didn't appreciate this until, you know,
21 I thought about it afterwards. And then he listened to it
22 and I mean, this man -- TV. And when it ended I said, "what
23 did you think of it?" And he said, "you know what? Space is
24 what's about my children's future." Those were the only
25 words that he could get out of his mouth. And here's someone

1 who's relatively uneducated, new to this country, but he
2 understood the criticality of space in the future of his
3 children. The connection was right there.

4 And sometimes when you're inside the Beltway and
5 you listen to the cynicism that comes out, you don't appre-
6 ciate that America wants to open the space frontier, people
7 on this planet want to open a space frontier, and they're
8 sick and tired of bureaucracy getting in the way.

9 And after that experience, all of a sudden there
10 was an unbelievable sizzle that took place. Galileo got to
11 Jupiter. I mean, if you think about the probability of that
12 happening, the Perils of Premalin. And then the miracle of
13 the incredible brains of the people that designed that mis-
14 sion -- it's breathtaking. You know, the margin for error,
15 assuming everything worked, was so unbelievably low, that you
16 ask yourself, how did it happen? And then shortly thereaf-
17 ter, I turned on the TV and there's an excited newscaster
18 showing a picture of Deep Field Galaxy. And I mean, as
19 excited as could be -- as excited as anything happening in,
20 you know, Bosnia, in Haiti, over the budget.

21 And then I had the opportunity to talk before the
22 American Astronomical Society a few weeks ago in San Antonio.
23 And I was going to talk about origins, and even though we're
24 talking about humans in space I'm going to talk about the
25 origins appropriate today and put it in context. And before

1 I give a talk I like to, if I have an opportunity, talk to
2 some scientists involved, so I had dinner with a number of
3 scientists. Jeff Mossey was there and Alan Dressler -- a
4 whole bunch of people. And I was all excited about talking
5 about talking about my subjects, and halfway through the
6 conversation Jim Mossey says to me, do you know what I'm
7 going to talk about tomorrow? And I said, no. And he
8 whipped out this data showing he had found two planets cir-
9 cling stars within 35 light years of Earth.

10 I mean. I couldn't believe what I was looking at.
11 And these planets were in the fuzzy life zone -- and I'll
12 talk about it -- I want to define that a little later. So,
13 if you think about it, or if we can pick a time in history,
14 all of history, you say, when do I want to be alive and when
15 do I want to be there? It's in 1996 and '97. I don't know
16 if you realize what's about to happen. We are finally get-
17 ting a chance to open the space frontier -- now, there's some
18 things we've got to fix, but you know, you talk to some of
19 these people, they say hey, wait till you see what I'm going
20 to show you next.

21 This is unbelievable. It's the type of thing
22 that -- they want to put it on Nightline. So instead of
23 worrying about the budget, why you know, we can't work as
24 Democrats and Republicans, as Americans together, here is
25 something that's definitely superior to this whole thing.

1 But we're not stopping. We have resources up there, we have
2 resources on the ground. Next week we're launching a MIR
3 space crew. We started on it three years ago. We didn't
4 debate it. We just started the program and we're building
5 it, we're launching it on the 15 February, and it's been
6 going out to an asteroid, and it's going to go into orbit 20
7 miles above that asteroid and we're going to learn almost
8 everything we have to learn. I know Gene Scheumacher still
9 needs some more data, and I'm sure we'll find some more mis-
10 sions for Gene.

11 And then this summer we're going to launch the Mars
12 Global Surveyor and the Mars Pathfinder. Three years, half
13 the price of one Mars Observer which disappeared. Every time
14 I go back to California they say, have you found Mars Observ-
15 er yet? A large lunar prospect in '98. We want to see if
16 there's water in some form -- goes to valuable water anywhere
17 in the solar system. 'Cause see, it's being launched earlier
18 than we initially projected. Close to a billion dollars less
19 money. It's going to be launched in October '97. No launch
20 start. The Cacidy is going to go to Saturn --.

21 We just started a program, I think a month ago.
22 It's called Stardust. We're going to go out and collect dust
23 from comets and then separately collect intergalactic dust.
24 And that the samples are coming back to earth. We're going
25 to launch that spacecraft -- we just started it. What if we

1 find some building-block of life in -- what else might we
2 find?

3 And then in the summer of '98 we're going to launch
4 Deep Space One. I made up the name. I didn't know what else
5 to call it. It kind of feels good. We are going, for the
6 first time after 30 years of development, utilize electric
7 propulsion. It's absolutely crucial for the exploration of
8 space, real advanced sensors are going to rendezvous with a
9 whole bunch of small bodies. And then, Mars in '98, launch a
10 global surveyor, Mars Lander II. And maybe even Mars Pene-
11 trator I. Then, in the year, 2000 Deep Space II. This is
12 going to be the first experiment in parametric techniques in
13 space based upon work we're doing with KEC-II and on Mount
14 Palomar in the barometer.

15 We thought the problem was going to be, to meet
16 forming networks and the neutrology, you know -- knowing
17 where things are when we land. People-meter and having
18 pointing accuracies of a fraction of a micro-off-second.
19 That's not the problem, although we don't know what the rest
20 of the problem is. But these are on the books, and we've put
21 them on the books even though the NASA budget's coming down.
22 Someone there in the press conference said, NASA's coming
23 apart. I don't understand. I just don't understand, because
24 people in the past measured the vitality of NASA by the
25 dollars going in, by how big an organization they had, by how

1 much paperwork they had, and how to buy by the bureaucrats in
2 Washington, and how much punishment could they inflict on the
3 nation.

4 I'm proud to say our budget has come down. We
5 started 25 new programs with 20,000 less people in this great
6 government. And there's going to be another 35,000 less.
7 And I feel on a human basis, that this is a vital and alive
8 program. Hubbel is going to be up there, and next year,
9 just about a year from today we're going to put in UV spec-
10 trometer, and we're going to put a new MIR imaging spectrome-
11 ter. Think about what's going to come out of Hubbel. And
12 it's not going to be done without people. They're going to
13 be astronauts to do it, and I'm proud to say there are going
14 to be astronauts. And we're working through the KEC Founda-
15 tion, and we're helping build KEC-II and this May we're going
16 to dedicate it and we're going to start getting first flight
17 in October of this year.

18 And then with the data from the Mount Palomar
19 interbarometer we're going to update the meet forming at the
20 KEC Observatory in Hawaii. And we're going to make inter-
21 barometric measurements and begin to get some sense about
22 extra solars of valuable light, and hopefully we'll detect up
23 directly from the ground, a whole bunch of Jupiter --. And
24 again we'll move forward. And then we're going to study the
25 earth's environment. We're going launch the Lewis Space-

1 craft, the Clark Spacecraft, the Trent Spacecraft, Topaz
2 follow along.

3 I noticed our French friends here. EOSAM-I, EOSPM,
4 Landsat, Sea Star. These are all going to happen, and start-
5 ing in '99, every year we're going to launch a new earth
6 science tool. So it's amazing that with less money things
7 are happening. We intend to open the space frontier, not to
8 provide jobs for people in the industry, not to provide jobs
9 for bureaucrats and not to provide jobs for bureaucrats in
10 universities (perish the thought, they're there too, because
11 they're not just in the government). We want people to work
12 with us who want to open up the space frontier. This is not
13 just intellectual. It touches the human spirit.

14 I took with me two issues -- I mean, I read lots of
15 publications, I could take bunches of them -- but look,
16 here's Time Magazine. The cover of Time Magazine. Not about
17 death and killing. It says, 'Is anybody out there? How the
18 discovery of two planets brings us closer to solving the most
19 profound mystery in the cosmos'. This says there's more to
20 life than survival -- that as human beings we need intellec-
21 tual nourishment as much as we need food, as much as we need
22 shelter. And it's built into our culture. And even more
23 stunning, this is -- I don't have my reading glasses on, but
24 I think this is December of '95. It says, 'Evolution's Big
25 Bang'. If you haven't read about it in either this or any of

1 the scientific journals, there's been some new findings.
2 That in a 10-million-year period, about a half-million years
3 ago, it seems everything happened. We went from a single-
4 cell to a most complex structure. One. And if we have a
5 sample of one, planet earth, I'm not sure we'll ever be able
6 to answer why. And for that reason alone, and I'll talk
7 about many others we need to explore.

8 So we shouldn't worry about just the day-to-day
9 things because they'll get taken care of, believe me. We
10 have 535 people in Washington worrying about the day-to-day
11 activity. What we have to do as scientists and engineers is
12 think beyond the next fiscal year, beyond the next quarter,
13 what's happening 20 or 30 years out, so that Bell Atlantic
14 technician is assured that his child will have a real future.
15 This is what drives me. I mean, every day I have to pinch
16 myself and say, oh God, look at the job you've got. What a
17 privilege that the President of the United States lets you to
18 go to work each day. And each day I say, whew, I made it
19 through another day. He may decide not to. And that's been
20 known to happen.

21 So what we have to do is have some unifying vision,
22 and that vision isn't, let's run short for the planet we
23 could go to. We have to think about asking some fundamental
24 questions and seeing how we tie science and commerce togeth-
25 er. And commerce is not a dirty word at NASA because sci-

1 ence, technology and commerce are absolutely integrally
2 aligned. And some of the feedback the American public gets
3 from the space program is the improvement in the quality of
4 life given the technologies we have today. But the real
5 payback is going to be when we open the space frontier and
6 make it part of our economic system. And that will be as far
7 away as we allow them.

8 So I'm here today to pose questions, tie issues
9 together, to explore issues, set goals, and talk about how
10 we're setting some thresholds. What I will not do today is
11 announce a disconnected feel-good mission. And I remember
12 on the 25th anniversary of the celebration of Apollo, there
13 was an unbelievable pressure: hey there, is NASA or the
14 President going to announce we're going to Mars? Absolutely
15 not. That would have been the wrong thing. Because then
16 we'll be back from where we were. We had this organic shut-
17 tle program. Now, I don't want to be demeaning to the people
18 that worked on the shuttle, but the shuttle has suppressed a
19 lot of science that we could be doing. There's no reason we
20 shouldn't have been doing these things 10, 20 years ago. So
21 we have to fight the temptation of getting an organic feel-
22 good program that could destroy the integration of what we're
23 trying to do.

24 Before I talk about this, I'd like to thank a
25 number of people I consulted with. Harry Holloway, West

1 Huntress, NASA Sam Vaneria, NASA Jeff Placia, Ann Balland. I
2 talked to Gene Scheumacher at the Galileo Penetration,
3 Transcordiva Kolchlosa, Mike Myer, Dr. Towns. I picked
4 everybody's brain, and I tried to synthesize some of the
5 thoughts that people have, because no one person has individ-
6 ual wisdom.

7 What I tried to do here is list what I consider to
8 be three fundamental, interconnected questions that we have
9 to answer. They're multi-disciplinary questions. It's not
10 about a spectrum or a mission -- it's about answering the
11 fundamental questions because the American public doesn't
12 know what a koseni is, but that know what fundamental ques-
13 tions are.

14 First, where do galaxies, stars and planetary
15 bodies come from? How do they evolve? Two, are there other
16 places that had an environment and in the broader sense of
17 the word, have an environment or might have an environment
18 hospitable to life and/or commerce? Three, is life of any
19 form unique to planet earth? And I think this is what --
20 this is the fine line I was trying to get at, and that I
21 think, is what turns people on. So this is not a program
22 I'll talk about today -- not a discipline, not an agency, not
23 a specific date, but in integrated, multi-disciplined, tech-
24 nological, cultural and economic quest.

25 We are interested in the sustained presence in the

1 solar system. We are not interested in rushing off to Mars,
2 spending tens of billions or hundreds of billions of dollars
3 and stopping the scientific pursuit so a few people can feel
4 good and a couple of companies will get big contracts.
5 That's not what we're going to do.

6 Now, to answer -- attempt to answer these ques-
7 tions, we could perform the following task. And again, I
8 think this has be decided by the people in this room, scien-
9 tists and engineers around the world, and I'm only proposing
10 these as a starting point and I hope they'll stimulate dis-
11 cussion. First, survey space to search for and analyze the
12 earliest formed galaxies. Two, search for and analyze stars
13 and planetary systems in the process of forming. Three,
14 search for and analyze extra-solar planetary systems in our
15 neighborhood. And our neighborhood is defined as, as far as
16 the aided eye can see. And right now it can't see very far.
17 It's blurry. We now are myopic. To search for and analyze
18 planetary bodies that were, are or could be, habitable and/or
19 could have resources of economic interest.

20 Search for resources and/or signs of life including
21 alternate life forms that we don't even know about. We just
22 found some alternative life forms at the bottom of the ocean
23 that don't operate the way other life forms operate, and if
24 we can have it on our planet, by God, we could have it on
25 others planets. In our own solar systems which we have yet

1 to go through and appropriately explore. Six, attempt to
2 determine some of the factors controlling the origin and fate
3 of the universe and our solar system. Everyone wants to
4 know.

5 And it brings to mind a story. I went to my daugh-
6 ters' school when they were in elementary school, and I
7 talked about the solar system: the sun, planets and planet
8 positions. And then I made the mistake of telling these 9-
9 year-old children, that the sun's going to burn out in five
10 billion years. They got hysterical. But these children were
11 giving an honest emotion. Think about our own feelings as
12 adults. So these are not insignificant questions.

13 And finally, and most importantly, to benefit
14 people in America and on the planet from the richness of the
15 findings and technologies. And you can do this in a single-
16 point program like Apollo. You can do this with a Sprint
17 it's America -- and it demands revolutionary change, not
18 evolutionary change. Let me give you an example.

19 The Hubbel Space Telescope. I love it. Six bil-
20 lion dollar life cycle. Unconscionable. You waste 25,000
21 pounds. It costs us a quarter of a billion dollars a year --
22 it's getting great results, but at what cost? And we have to
23 get into more of a cost-benefit analysis. So I challenge,
24 and I'll talk about it later, people in this room and people
25 across the nation and I'll talk about how I think you can get

1 this without being specific. We need more than an order of
2 magnitude reduction in weight. We needed at least a factor
3 of 20 reduction in force. And we needed at least a factor
4 of two or three to reduce the size of that telescope. And
5 that technology needs to be developed by next spring. We
6 could do it.

7 People out on the west coast -- in fact, I saw
8 Roger Angel here. Roger tells me he can do it -- he's a
9 little too heavy, but he can get it down a little bit. So
10 everything is connected, and new relationships between indus-
11 try and academia and government and the American people have
12 to take place. The Apollo era is gone. America spent five
13 percent -- five percent of its budget to go to the moon
14 because we had to beat the Russians, and that was the right
15 answer. Our budget is now nine-tenths of one percent. So I
16 will fight anyone that wants to rush forward for a feel good
17 mission to the moon, that doesn't have revolutionary technol-
18 ogy -- not for the technology sake, but we need orders of
19 magnitude of reduction in costs, so we get the cost down, the
20 ratio so industry could begin to think about getting in-
21 volved. So 20th Century thinking is out, 21st Century think-
22 ing is in.

23 Now, if you take a look at NASA, a solid revolution
24 happened -- a week ago and I don't think anyone noticed it.
25 NASA is no longer an object-oriented program. We no longer

1 have a space physics division to serve the space physics
2 people in the university system. We no longer have a plane-
3 tary division that has a community that needs so many hundred
4 million dollars a year. We no longer have an astro-physics
5 division. We have intellectual leadership at headquarters
6 based upon questions that need to be answered, and multiple
7 disciplines. We no longer organize ourselves around wave-
8 lengths. We no longer feel constituent-oriented to people
9 who go to the Congress and have to have a specific level of
10 budget so that they don't have to lay people off.

11 Now, I don't want a peer office. We've got to be
12 dominated by work that's outstanding, and the work cannot be
13 subsidized by the American people -- to provide stability in
14 laboratories. Your work's got to make it through free-flow-
15 ing peer review research, and not from the Congress. And
16 this has hurt the NASA program. Nobody's mad, but sit in my
17 office sometime and you'd throw up from the calls you get
18 from the Hill -- good people on the Hill -- because people
19 are trying to maintain the status quo and the NASA-team is
20 bound together and determined, never again.

21 So, we have a shared vision. We're going to look
22 at the planetary system, not as planets in our solar system.
23 We're going to look at our planetary system as every possible
24 planet that we can see with the aided eye. And we intend to
25 do relative planetology. We intend to get ground crews from

1 what we can see with robots in our solar system -- with what
2 we can see where appropriate, the people that walk on planets
3 in our solar system, or we can see remotely in nearby suns.

4 So what we have done is, we have taken the program
5 responsibility away from NASA Headquarters. It's gone, it's
6 finished, it's done. We've actually pressed the people in
7 the field centers, we've identified new field centers'
8 functions, and we're out of command and control. No more
9 people control -- no longer will people control the holds
10 that NASA had at Headquarters, looking for hot dog stands.
11 We're shutting down every scientific hot dog stand, and
12 everything must be related to the strategic plan for NASA,
13 and everything must be related to answering basic questions.

14 And we're open. We want the scientific community
15 to come back at us and say, hey don't think the questions
16 should be this way, they might be that way. But we're commu-
17 nicating with the American public -- from online on the
18 Internet we get an unbelievable amount of hits, and we want
19 to work together. We've got to close all these hot dog
20 stands because as our budget comes down, it's not allowing us
21 the kinds of research that need to be done. So for our part,
22 Headquarters will no longer be measured in multiple thousands
23 of people, it's going to be measured in the methods that
24 people use. Good people are going to go to the centers, and
25 good people may no longer be with the Agency.

1 I don't want you to feel there are bad people, but
2 this is a fundamental change in the seascape. Headquarters
3 will determine the what and why, centers will determine the
4 how. We will not usurp the responsibility of the new
5 center's directors. Engineering is going to be a short-cycle
6 point. As a general principle by exception, we won't start
7 programs beyond three years from start to launch, unless
8 there's some real compelling reason. We'll demand that all
9 the technology get done in advance. You could have
10 experimental programs, you could crash ex-planes, you could
11 do whatever you want. Once you start with we're going to
12 finish unless there's some rule of physics that says you'd
13 have to in three years.

14 Low cost. Each mission has to be less money than
15 the next, because your budget's coming down and it's not even
16 getting corrected for inflation, and we want to start new
17 things every year, and that's how to do it. We will have a
18 technology pipeline. In the past, every program had to have
19 their own technology, and now we're setting up the technology
20 pipeline for launch, setting up the technologies pipeline for
21 spacecraft, and we're not going to fund technology on a hot
22 dog stand basis. They all be covered -- based on --.

23 And it brings to mind a question a young engineer
24 asked me -- I was at a job, maybe about three or four days.
25 And this young engineer said to me, Mr. Goldin, I have a

1 problem. I found a new device that no one will fly. I go to
2 the program managers and they say, has it flown before? And
3 he says no, so they say to me with a pat on the head and the
4 back, go away young fella. Go get it tested and then I'll
5 fly it. You know, hell is a Catch-22? Well, we are now
6 sending up a series of spacecraft that are going to be tech-
7 nology directed so we can test these new technologies out so
8 when we go into the missions, we don't have to have risks.

9 This is the concept and, I'll tell you, I've got to
10 thank one person in this room here, Jerry Fennell Banyon.
11 Early in my tenure he talked to me about this experimental
12 concept and a number of others. Really competitive things,
13 and I probably -- . So we now have the tools, we now have
14 the approach, and now we have the planetary approach that
15 we've broadened up.

16 So how do we go at it? I propose that you consider
17 that there be four phases to planetary exploration. I'll
18 call Phase 1 robotics precursors. This is where you can
19 throw flyby, orbiters, landers, rovers, sample-return devic-
20 es, to kind of scout the land. To find the places that have
21 some real potential. Phase two would be initial human explo-
22 ration. That first few flights -- you don't have to plan it
23 for a whole long series, just the first few flights.

24 Then as you get more data in the, you know, the
25 cost benefit ratio starts getting better, the potential for

1 scientific resources or commercial resources appears, and as
2 the cost goes down that ratio is really sharp. You then go
3 into rebustion of exploration. And then finally, you go over
4 the threshold, to phase four, sustained human presence. And
5 I think we need to think about these different thresholds
6 because we mix our metaphors. When we talk about missions --
7 hey, I want to go to Mars. Well, what the people generally
8 say is, give me the price for that first flight. And that's
9 unfair to the President and that's unfair to the Congress and
10 that's unfair to the American people. And these phases have
11 a hierarchy. It's a resolution of spacial, temporal, spec-
12 tral, analytical, and adaptability to tools.

13 Let's take a look at them. The lowest spacial
14 resolution, the lowest specialized resolution is going to be
15 the telescope on the ground. We've done it for centuries.
16 And the first big leap is to take the telescopes off the
17 ground and to put them into space, then get rid of the
18 earth's atmosphere. Ultimately the telescope's going to have
19 to leave earth's orbit. We're going to have to put the
20 telescope out at about 5 AU's, so we get rid of this desire
21 for light, if we ever want to look at planetary systems
22 around nearby stars.

23 And then you get better resolution by going through
24 a flight and that's what we did with Mariner II to Venus.
25 And it opened up our eyes. Then we orbited the moon, the

1 lunar orbiter in the Mariner series. And then we landed the
2 Surveyor and Viking. I mean, that was it. We haven't landed
3 on a planet for 20 years now because we've been so excited
4 about the service award contracts on the shuttle that we're
5 not doing science. We spend \$10 Billion on the space station
6 and didn't produce a piece of hardware, but boy, do the
7 contractors have fun.

8 It is shameful that stealing from the American
9 public -- and these are good people -- but we have a bad
10 system and we've got to wipe out this bad system. And we're
11 getting there. We've made tremendous progress. And then
12 after we land in fixed positions, we've got to roll. We're
13 not going to wait two more decades to roll. Within days of
14 the find that the Mars Orbiter was lost, we started the Mars
15 Pathfinder. At one-quarter the cost, we're going to land a
16 Rover on that planet that could move out around without
17 command first. We say, go from here to there, it will figure
18 out where the rocks are and will go around the rocks. It has
19 its own eyes and it has -- I don't want to say a brain, but
20 it has a reasoning capability, and that whole rover may have
21 cost \$10 Million. Maybe 15. It didn't cost a good fraction
22 of a billion dollars. And they're building the whole thing
23 in three years, and if they launch it for Mars and it doesn't
24 work, I'm going to hug that team for having the courage to do
25 it because they want people to take risks. The spacecraft

1 are less expensive and we could afford failure because we've
2 got to push the technology in these areas.

3 And then after we rove we bring back samples, or we
4 can put an instant new lab on there like we had the Viking
5 biology lab protection. That trade isn't very clear to me.
6 I think it will probably make sense to bring the samples back
7 so we don't have to miniaturize a chemical and physical lab -
8 -. So Stardust is our first sample return, and we don't have
9 to wait until the middle of the first decade in the next
10 Century to do it. And then clearly, you've got to put people
11 on the surface when we find out that we exceed the threshold
12 of the cost benefit ratio.

13 Apollo was enabled by the technology of Saturn and
14 the numerous --. Jack Schmidt found active --. Now people
15 say to me, then why don't we send rovers? Why don't we sent
16 robots to do this work? To which I respond, the minute you
17 show me a robot that roves the earth doing -- geophysics, at
18 the very moment I'll send a robot, at you know, 10,000 times
19 the price, and put it up on a planet. It doesn't have cogni-
20 tive ability yet, it doesn't have versatility yet, it doesn't
21 have manual dexterity yet, and it doesn't have adaptability
22 yet. Now, maybe when some of these robots come into being,
23 we won't need people for that aspect, but we still need the
24 cultural aspect. And people are going to inhabit other
25 planets at some time, I don't know when, and it won't just be

1 robots, it won't just be --.

2 So the challenge is to figure out what are these
3 cost benefit thresholds between Phase I and Phase II, Phase
4 II and Phase III, Phase III and Phase IV. And it could be
5 scientific, it could be economic, and it could be cultural.
6 And I say, we would not ignore it. I'm not saying overplay
7 it, I didn't say overdo it for money, but if there's a comm-
8 ercial benefit or scientific benefit, people of the United
9 States or people around the world are going to pick up the
10 bill, and you've got to factor in communications that do not
11 put science into a black hold.

12 And I want to tell you, we've made very little
13 progress since I begged this organization a year ago, to get
14 the scientists to start communicating with the American
15 people. We haven't made progress. I've probably been in 20
16 or 30 cities since I gave that speech and people are still
17 saying to me, I'm not seeing --. You need to do better, I
18 need to do better, we need to do better.

19 Now, let's take a look at some of these scientific
20 benefits. And again, you can make your own list, but I've
21 made mine and I'm speaking -- decide whether you like it or
22 not. First, and probably one of the most compelling, are
23 there present or past forms of life at any level. If we
24 could find a fossilized, singular-cell life, it would change
25 a lot about how we think of ourselves. How is the planet

1 structured and how did it evolve and what are the implicati-
2 ons to the earth's evolution or general theory of evolution
3 of the earth? Can we unravel the body's climactic history
4 and environmental history so we can better our model for the
5 climatic understanding, because when you start doing climac-
6 tic experiments you need a laboratory the size of a planet.
7 You can't get some of these -- performance of planets --.

8 From an economic standpoint, the most compelling
9 issue is, can you find resources to live off the land? And
10 in fact, if you ever want to get to Phase II from Phase I,
11 you must have that, because it's going to be too expensive,
12 as Bob Zubrin points out, the load-down of spacecraft with
13 all the breathing gears, all the fuel to go there, to stay
14 there and come back. So I would say it is my intuitive
15 feeling that you almost have to say finding resources to live
16 off the land has to be a condition to go from Phase I to
17 Phase II.

18 Second point on the economy is, are there natural
19 resources in the broadest sense, of economic value? Are they
20 environment conditions conducive to manufacture of high value
21 products, because of the environment that you have there that
22 gives you unique cost and performance better than what we
23 have on earth. And there are a whole variety of parameters -
24 -. And maybe, just maybe, -- have -- reality.

25 Now, when you think about geological fieldwork, and

1 you look at this article in Time Magazine, you know, the
2 geologists made -- the paleontologists made a trade. They
3 took a look at Landsat pictures perhaps -- I didn't get into
4 their brain -- they took a look at other things, and they saw
5 there's some places in Australia that offered some promise.
6 Did they send a robot to Australia? No, it was a cost bene-
7 fit to get a plane ticket and rent a car to go to the site
8 themselves. And they went to this. In other cases it made
9 more sense to send a robot, so when they went to the bottom
10 of the ocean to make some of those measurements, they sent a
11 robot.

12 And this is okay. You don't have to have robots
13 and you don't have to have people. But you do this horse
14 trade so that it makes sense, and then you proceed forward
15 instead of making macho statements saying, I'm going to go,
16 follow me. That's what happened with efforts like -- Presi-
17 dent Bush genuinely believed this was the right thing to do
18 and to me, NASA let him down. We led him down the garden
19 path because we didn't tell him how much. How much was a
20 quarter to a half trillion dollars measured over 30 years?
21 You know, it dims the light on the gross domestic --. This
22 is not the way to do space science. So we need to really
23 think through this cost benefit analysis.

24 Now, let me define what I mean by the life zone,
25 because I know there are those who say the only place to go

1 is Mars. It may be the only place to go, but if you think
2 about that the definition of the life zone is in the broader
3 sense, I think we may open up our minds. The life zone is
4 not the range of distances between the sun, where convention-
5 al thought says that water will be stable. And we, you know,
6 it won't oil, it won't grease. It's much more encompassing.
7 It's a multidimensional space of temperature, pressure,
8 composition and time, in which conditions necessary for life
9 could, does or did, occur. Very important to think about
10 that.

11 So the robots have begun to explore what that life
12 zone is in our solar system and they'll define the life --
13 they've begun to define a life zone in another solar system -
14 -. The earth, we can go down to Antarctica -- Chris McKay is
15 here, he's done that. It helped us to figure out where to go
16 on the Viking, except the data came two months after we
17 launched it, so we went to the wrong place to search for
18 life. You know, we look at the deep oceans and we see other
19 characteristics and we look at Australia. Now, Mars looks
20 like a place that might be right, and we all know -- most of
21 us know the arguments about Mars -- might enough water,
22 comets and asteroids could have landed there with the build-
23 ing-blocks of life, there are dry lake beds. There are all
24 the conditions conducive that life could have or might exist.

1 And we're going to begin to get a sense about that.
2 But we have to look at complex environments to interplay with
3 geological processes, chemical processes, physical processes,
4 biological processes, and a whole host of transport process-
5 es. And these are the things that produce the conditions we
6 can't always predict or imagine.

7 Now, let me pick a wild and crazy -- in the summer
8 of this year we fly by Uropa. First blush from Voyager says,
9 ah, it had these cracks that come and go. Maybe the ice is
10 healing itself. And then when you take a look at it, the
11 gravitational pull could be putting enough energy into the
12 core of this body that we might have an energy course. And
13 then if you look at the density, looks just like a conditic
14 meteor. And that has building blocks of life. So if you
15 look down to the earth's ocean's floor, in the deepest chan-
16 nels on earth, maybe we might find the kind of life there
17 that might be on Uropa. Who knows? I don't know.

18 But I certainly keep an open mind and when we think
19 about where we're going to go next, I have deep respect for
20 what I don't know about. But who knows, it might have a 10
21 kilometer-thick ice crust, on a 100 kilometer-deep ocean.
22 Who knows? Venus, maybe billions of years ago, could have
23 been in the life zone. Today it's not. Vavoom. What if the
24 Lunar Prospect finds ice -- South Pole. Who knows? I want
25 to tell you, there's going to be one beeline for the moon.

1 All sort of possibilities. Maybe Titan -- once it's there in
2 '97. And as Gene Scheumacher points out, water -- on the
3 earth's asteroids. There could be a wealth of possibilities
4 in those asteroids.

5 And then, not only do we have the possibility of
6 life, but we have the possibility for some ground crews.
7 Think about Uropa, and think about the moons that might exist
8 around these planets that we just have found. What if we get
9 some ground crews? We have to understand life here and be
10 open and imaginative. Let me just give you one little specu-
11 lation. Let's say we find an earth-sized, blue-green planet.
12 You say ah, we found life. What if we found a blue-purple
13 planet? Should we stop? Maybe we've got photosynthesis from
14 rhodopsin, and maybe life might be the same, except it's
15 rhodopsin instead of chlorophyll. So we have to keep open
16 minds.

17 So the possibilities are great but there are limits
18 to what we can do. The National budget's coming down, and
19 before we can even think of stepping foot off this planet, we
20 have got to fix, the festering, nagging, shameful problem
21 that we have in this country --. I'm embarrassed, I am part
22 of the problem. I feel we have not served our country well,
23 yet every time we go forward with a new launch vehicle, the
24 scientists are worried about their programs. If you tell
25 your scientists that unless we have a launch vehicle there

1 will be no science, that it can no longer afford \$10,000 to
2 \$20,000 a pound.

3 And I testified under oath before the Congress that
4 the highest priority for them to start at NASA, was to fix
5 this and go on to a different problem. Even if the budget
6 comes down, we will cancel programs, never again are we going
7 to pay the price we paid, in renewing old ballistic missiles
8 that my company system engineered in the fifties. I'm embar-
9 rassed for our country. Good people have been living with
10 the status quo, and if this doesn't change, we can talk all
11 we want about space, we can talk all we want about -- , we
12 can talk all we want about instrumentation, because we have -
13 -. And it's not going to happen with an organic program.
14 Let's throw \$10 Billion in it. So -- a little, build a
15 little, test a little. I'm going to keep the program a small
16 size so no one will get rich immediately. The place to get
17 rich is after you figure out how to do it in an order of
18 magnitude of less money. After you get into that shuttle,
19 after two minutes there's nothing we can do. All -- bail
20 out.

21 But we've got to be honest with the American public
22 and not deceive the American public that they're getting
23 something that they're not getting. They can no longer
24 afford billions of dollars a year with tens of thousands of
25 people hugging the shuttle. There are some people who think

1 the shuttle is the ends, not the means of the program at
2 NASA. Now, it's a wonderful machine and we're going to make
3 that machine as safe as humanly possible. In fact, the
4 reliability on NASA end on the last three years has -- be-
5 cause we invested money to make it that way so the astronauts
6 would have more confidence getting in.

7 But there are those who think they're going to keep
8 the shuttle program alive to the year 2025, and I want to
9 tell you, they're whistling Dixie. Unfortunately, this crew
10 is in agreement. Come to an AIAA meeting and you'll see --.
11 I mean, we are taking money from science and putting it into
12 bureaucracy. Where is it said you need 20,000 people to
13 build a launch vehicle? But given that fact, I'm proud that
14 we have a safer vehicle that a million dollars --. This
15 money helps fuel --. So that's the first item on my list,
16 and probably the second, third, fourth, fifth and sixth.
17 That's the only way we'll leave this planet. That's the only
18 way we can do a mission like --.

19 Then we have to second, figure out how people could
20 live more safely and efficiently and productively in space.
21 You can't paint people in a 1 g environment and throw them
22 into cosmic solar radiation, zero gravity, and say have a
23 nice day. There are fundamentals of life science that have
24 to be undertaken, and this is where we as an Agency, must nod
25 to the medical science, life science, biotech -- all the

1 computers in this country. NASA will no longer be about
2 rocket boosters when we fix that trouble. NASA's going to be
3 about life sciences, about how to hermetically select --
4 cosmic, solar --, -- radiation, life support. How do you
5 control microbial elements for two, three years. It's a very
6 small environment, without getting a Legionnaire's disease.
7 But if you get Legionnaire's disease, what do you do? How do
8 you make a personal life support system? A space suit -- it
9 cost \$10 Million. It costs, you know, a good fraction of a
10 million dollars every time you use it. The object of the EPA
11 suit is not to make people wealthy or give them jobs. The
12 object is to protect the vehicle activity.

13 Microgravity affects the heart, the muscles, the
14 bones, the immune system, the nervous system. By studying
15 how to get countermeasures to them, we'd better understand
16 human physiology so we can enhance the quality of life on the
17 earth. We need new concepts in medical care. You know, on
18 Apollo we invented intensive care monitoring, and some of the
19 people in this room have had to have these little battery
20 packs you carry around. Just about this big, looks like a
21 transistor radio. We intend to put that on a microchip that
22 you can't even see, using nano technology. And in fact,
23 right now some of this technology is being used at the Uni-
24 versity of San Francisco to put implants into children that
25 are still in their mother's womb so you can monitor their

1 vital signs --. So it's not in the future. It's here.
2 Chemical surgery, select and induce resistance to illness.
3 Calimedical Support -- these are going to be done in the
4 space station and ground support.

5 This is science, this is important science. We
6 have to figure out to make robots and how to integrate them
7 with humans. We are on a path to develop robots that think,
8 see, hear, touch, smell, speak, talk, perform mechanical
9 operations. Right now we robotics assistants. By the time
10 we get done with the space station we intend to have robotics
11 surrogates --. And we'll go into testing in space. When we
12 put the astronauts in space they're not going to do into
13 space with 400-pound space suits and at least 10,000 hours of
14 -- .

15 Third, we need tools to produce higher resolution
16 spacial, spectral, chemical, and life cycle of course, sci-
17 ence space base stations. And here is the concern. Let me
18 use the Hubbel space telescope as an example. Hubbel is as
19 safe as every other telescope we've put in space. Because
20 we've built telescopes -- we take huge pieces of heavy glass.
21 We said uh-huh, when we built a space -- telescope we'll do
22 the same thing. And then on the ground, because of gravity,
23 we need an ultra-stiff structure. I mean, short of --. So
24 we made this thing so darned stiff that you don't have to
25 worry about any problem.

1 So then what we do is, we take the same technology
2 and we try to put it on a launch vehicle. And so we get a \$6
3 Billion, 25,000 pound wonderful Hubbel telescope. What we
4 need to think about, and will open our mind, is instead of
5 rigid trusses, get the rigidity --- . Use floppy structures
6 and go to adaptive structures to correct dynamic problems and
7 cause these static problems. Control the surface of the
8 optics so you don't even have to test it on the ground, and
9 figure out how you take this -- thin, put it into space,
10 deploy it, have it -- control. Now, I'm not talking about
11 tomorrow, but we've got to leave our old ways if we ever
12 expect to get a factor of 20 to 30 reduction in cost --.

13 Now, I want to tell you, I just read a ski maga-
14 zine. K-2 Ski's has the following ski -- which I will buy
15 next week when I go skiing in California. It has a ski with
16 a pysio-electric device, so when you go over bumps you build
17 up a charge on a capacitor which then gets dissipated, the
18 resistant of the skis don't vibrate. Now, if K-2 can build a
19 ski to do that for a few hundred dollars, we ought to be able
20 to build an optic twice the size of the Hubbel Space Tele-
21 scope. An adaptive optic. We ought to be able to make that
22 one-tenth to one-thirtieth the weight, and one-tenth to one-
23 thirtieth the weight and one-tenth to one-thirtieth the cost,
24 and all of a sudden we could see anything we want to see.
25 Maybe I -- . This is important stuff. And then, instead of

1 grinding things, we ought to replicate services, and instead
2 of grinding and polish, we ought to think focus. It's a
3 whole new way of thinking, that you can apply this active
4 control of a large space --. And they're building systems in
5 space with zero G precautions.

6 Now, the first task that I talked about, the lead
7 center, this NASA module. I told them, shut the hot dog
8 stands down, and all you've got to do is work within this --
9 academia --. NASA Johnson's been worried about operating a
10 space station and figuring out how people can live and work
11 in space. Jay Piel, worked with academia and industry,
12 resolved this problem.

13 The fourth problem is probably the most difficult,
14 and not necessarily the least priority. There's revolution-
15 ary change in design, simulation, and analytical tools.
16 We're in the dark ages because of tools, and I ask you to
17 think about this. We have \$9 Million in --. If you fail a
18 composite it doesn't yield, it explodes. We have complex
19 environmental inputs, we have stochastic processes and non-
20 deterministic systems. Now you mix all this stuff together
21 in a ball and say, where's my design crew? It's non-exis-
22 tent.

23 First of all, if we're going to work with compos-
24 ites in some of these master --, we need a physic's-based
25 design crew to start with the individual molecules and the

1 forces between them. It builds up -- design -- , and started
2 --. But this is the type of thing we would hope we have --
3 this is a perfect job for academia. This is the kind of
4 thing that needs to be done. We have these designed, but we
5 designed in black plastic, do you know what I mean here?
6 Black aluminum, designed in black aluminum, you know, when
7 you take composites and you do safety factors like you use in
8 the -- but it's non-elastic. It's not isotopic. It doesn't
9 make any sense. Beechcraft tried that with that starship,
10 that's why it failed. They designed in black aluminum. The
11 University community needs to work with us to build these
12 physic's-based --.

13 Then when you think about what has to be done when
14 you get adaptive, intelligent, learning, self-generating,
15 software to deal with the chaos and the sheer magnitude
16 involved in --. And then we need computers to go along with
17 that. And may in the -- of things we went --. Genetic-based
18 algorithms could provide stable, state change of complex
19 systems, and we are working on this. The other problem is,
20 travel is too expensive. People get on planes, still today,
21 because we don't have geographically distributed user-friend-
22 ly tools to allow collaboration. So we need interconductivi-
23 ty, interoperability, -- with common media and low cost.

24 We have just changed the mission of NASA Ames. I
25 called them, stop hugging with the --. Let go. Let's take

1 the science mission at NASA Ames, and turn it into an insti-
2 tute and let's focus NASA Ames, that's right in the center of
3 the information capital of the world, into the center of
4 excellence of information and technology in the world, so we
5 can develop these tools. And we're starting with the entire
6 industry, we intend to have a virtual laboratory for develop-
7 ing the multimedia tool. Right now the duties --.

8 So these are the type of things -- now, anyone can
9 make their own list, but I think these things go to the heart
10 of the problem, and these issues get back to scientific
11 fundamentals, started at the beginning with the molecules.
12 So I'm finally confident that we'll be able to do all the
13 things that one can name in one vision.

14 Let me ask you to think about this. A few decades
15 from now a young lady, who is the daughter of this Bell
16 Atlantic technician -- and she's going to be sitting in her
17 office and she'll be looking at a number of images in this
18 picture-framed video display on the wall. And she'll be
19 looking at direct action and analysis of certain planets, and
20 she will have seen a planet, and if we didn't have enough
21 resolution to see ocean, continents and clouds, but because
22 the planet was spinning we had a few pixels, she was able to
23 observe some ice caps, she was able to observe some -- varia-
24 tions and typical galactic characteristics --.

25 And she also took the data in an office when a

1 mission that she helped lead before she got that job, to land
2 the first U.S. -- , and the first demonstration phase of the
3 mission. So perhaps, just perhaps, something would happen.
4 She was waiting, the phone rang, and a NASA administration
5 called and said, don't come to Washington, -- free. They've
6 got to show you something. Perhaps they and the rest of the
7 world sees something that changes history. Something that
8 changes what it means to be a human being, and perhaps, just
9 perhaps, they would see something that suddenly forever
10 changes. Thank you very much.

11 * * * *

12 (Q & A session with audience)

13 UNIDENTIFIED VOICE: --

14 MR. GOLDIN: I have not spoken to him.

15 UNIDENTIFIED VOICE: --

16 MR. GOLDIN: I understand. I mean, I try and talk to as
17 many people as I can. I'll be happy to talk to him.

18 UNIDENTIFIED VOICE: --

19 MR. GOLDIN: I understand, and, I will do that. I will
20 take it down, and if you give me a card, I'll tell you what
21 he said.

22 UNIDENTIFIED VOICE: --

23 MR. GOLDIN: What's that?

24 UNIDENTIFIED VOICE: --

25 MR. GOLDIN: Oh, Time Magazine -- my eyes are old eyes -

1 - it looks like December 4th, '95. -- has good eyes.

2 UNIDENTIFIED VOICE: -- December 4th --

3 MR. GOLDIN: December 4th, it has -- right. Yes sir?

4 UNIDENTIFIED VOICE: That's an inspiring vision you
5 sketch, but you're not going to -- a space station in partic-
6 ular -- could you expand on that for a bit, please?

7 MR. GOLDIN: Well, I appreciate your comment, and let me
8 respond to it. The space station is being built to see how
9 people can live and work safely and efficiently in space.
10 Now, if you want to test someone at zero gravity, you can try
11 to do it on the earth and you get 28 seconds -- ballistic --.
12 If you want to expose someone to years of zero gravity and
13 get real --, real sophisticated and medical -- , the only way
14 we know how to do it is to go into an orbit --. And we know
15 in an orbit we keep -- by going -- orbit around the planet
16 earth. If we want to go test robots in zero gravity, we
17 don't know how to do that and have those robots -- direct --
18 29 seconds.

19 There are a whole host of issues. If we want to
20 really test how to obtain samples and bring them back to
21 earth -- because if we bring back specimens -- there are a
22 whole -- microbial -- . You can make long, long lists, so,
23 sometimes people think about, oh, the justification for the
24 space station is to do microgravity of myself. The justifi-
25 cation of the space station is to figure out how people can

1 live and work safely and efficiently in space.

2 That's something we have to do, and then because we
3 set up this unique facility -- we have 100 kilowatts of elec-
4 tricity, we have a pressurized volume equal to the size of
5 two jumbo jetliners, we have 14 of the most developed coun-
6 tries of the world participating, we have six researchers on
7 board, probably one and a half will be tied up with mainte-
8 nance. We can do stunning science, I want to tell you. Even
9 in that domain, even though that isn't the justification, we
10 are getting stunning results. Biotech to biomed -- . Test-
11 ing Nobel prize theories. The theory of space -- . So it is
12 there.

13 Now, the point I want to make is, the reason the
14 space station got into trouble in the first place and we kept
15 debating it, it is no longer a debatable issue. We are going
16 to build the space station. That's why we spent \$10 Million
17 in 10 years and got nothing, because NASA tried to please the
18 Congress. A responsible parent sometimes says, "no". We're
19 saying "no" to redesign, we're saying "no" to changes, and
20 we're going to build a space station. We are less than two
21 years away from launch. Now, we set that schedule in October
22 '93. And unless there's some act of God we can't control,
23 we're -- .

24 We have a reserve -- and the other thing we did
25 that's unique is to set aside \$2.6 Billion reserve for sci-

1 ence. Engineers cannot touch one nickel of that science. The
2 problem we had is we had a solution seeking a problem. We
3 now have a problem seeking a solution.

4 And the other thing I want to tell you -- and this
5 gets back to a point that was made with Gene Scheumacher in a
6 press conference -- someone said, Gene has an idea that --
7 ask -- approval. I got a little cute and said "no". What I
8 really wanted to say was, we have these thresholds to go
9 through, and if Gene can make it through the process, and it
10 will be a peer review process -- it will be a national peer
11 review -- if he makes it through, and this is the priority in
12 -- mind. Now, his argument is, it's less expensive to go to
13 an asteroid then it is to go to the moon because there's
14 almost no gravity on the asteroid and you don't need delta V
15 going down and going up. And he says the scientific riches
16 on the asteroid has great possibilities.

17 Now, one of the things I didn't talk about was, we
18 would like to have some demonstration missions and just
19 causing -- Phase I and Phase II. It's a real quick -- force
20 mission to prove out the technology and savings. And one of
21 the things I did was, I challenged the folks down at NASA
22 Houston. I said, it cost \$11 Billion on a current basis and
23 \$94,000 -- on Apollo. I give you the following -- exper-
24 iment. Go to the moon -- you're getting no money to do this
25 stuff -- figure out how to go to the moon, land two people on

1 the moon, keep them there for three days, bring them there
2 and back safely, no other requirements. And then I said,
3 figure out how to do something similar for an asteroid but,
4 number one, something in the range -- fact -- Apollo --
5 basis.

6 They weren't afraid. And right now, we'll see how
7 they go. I wouldn't want to -- I don't want to usurp what
8 they're going to say a year from now. And I said, no outside
9 contractors, you can't have thousands of people. I want you
10 to sit in a room, I want NASA to start getting technical
11 instead of being contract managers. And then we'll ask
12 contractors to do this later. But I want to re-establish and
13 try -- next -- NASA. They told me that we could go -- and I
14 had fun doing this also -- Apollo was 136 tons in their
15 calculations -- . Very different.

16 But you know what they said? The thing that's
17 killing --. And that's why when Gene -- someone said, well,
18 will his asteroid mission go, the sooner we get margin of
19 control I feel will get -- asteroid. He may -- that may be
20 the very first mission we're going to perform, and that's
21 administrative -- technicians, I tried to.

22 Thank you very much.

23 (Lecture concluded.)

24

25

C E R T I F I C A T I O N

I certify that the foregoing is a correct transcription of the electronic sound recording of the proceedings in the above-entitled matter.


Linda Raitala
DEPOSITION SERVICES, INC.


DATE

AAAS

February 9, 1996

Remarks Prepared for Delivery by:

Daniel S. Goldin

Administrator

National Aeronautics and Space Administration

Intro:

(Story about Bell Atlantic/fax line installation)

In preparing for this talk, I collaborated with a number of people. Their insight and expertise were invaluable to me, and I'd like to give them credit.

I'd like to thank Charles Townes, Wes Huntress, France Cordova, Harry Holloway, Dan Mulville, Jeff Plescia (Play sha), Carl Pilcher, Mike Meyer and Sam Venneri.

Exploration of the Universe and the Search for the Origin of Life

Three fundamental questions help drive our science program at NASA:

1) Where did galaxies, stars, and planetary bodies come from and how did and will they evolve?

2) Are there other places that had an environment, have an environment, or might have an environment which is hospitable to life?

3) Is life unique to the earth?

Over the next several years, we will:

- Survey space to search for earliest forms of galaxies,
- Search for stars and planetary systems in process of forming,
- Search for extrasolar planetary systems,

- Search for Earth-like planetary bodies that were, are, or could be habitable, and/or for resources of economic interest,

- Search for resources and signs of life (including alternatives forms of life) in our own solar system and bodies which we have yet to go to or observe,

- Determine the factors controlling origin and fate of the universe and our solar system.

Ground truth for this quest is the exploration of our solar system. We want to learn how it formed and evolved and whether life ever evolved anywhere beside the Earth -- both within this solar system and in other solar systems, and are there any resources anywhere of economic interest.

In our search for extrasolar planets, we are today like Lowell was in the early 1900s in his observations of Mars. Staring out of his telescope on Mars Hill in Flagstaff, he studied Mars. He saw color changes over the

seasons and other features. He interpreted these as canals filled with water and vegetation and concluded that there was life on Mars.

Lowell's problem was that his ground truth was too narrow. He only knew about the Earth. He couldn't conceive of how different Mars might be.

We must not make the same mistake. We must ensure that our ground truth is as broad and inclusive as we can make it. We're not there yet. We look out at other star systems and see things, but we don't yet know how to interpret what we see.

We have to shed our preconceptions. We have to be open-minded. What we find may not be what we're looking for.

Part of the problem is resolution. Part of the problem is learning more about our solar system and how solar systems form and evolve. With time, our resolution will increase. And we will be better able to understand what we see.

Ground-based observations are part of the robotic phase of extrasolar planet detection. The Hubble Space Telescope represents the next step in that robotic phase. It will be a long time before we enter the realm of human exploration of other star systems.

We are redefining the idea of planetary exploration. We are broadening and diversifying the definition --

Planetary exploration will no longer just mean bodies orbiting our sun. It will reach as far from the Earth as we can see. It will include remote sensing observation and sending probes to investigate the phenomena we observe from Earth. Ultimately, we'll bring back samples and send humans out to touch those bodies directly.

In the near term, our exploration will be with robotic missions within our own solar system; outside the solar system we will observe using remote sensing techniques.

There are four phases of planetary exploration:

- 1) Robotic Precursors,
- 2) Initial Exploration by Humans,
- 3) Robust Exploration by Humans,
- 4) and Sustained Human Presence.

There's a hierarchy here based on resolution. We'll reach out from the Earth and move outward with every increasing resolution. Each step in this progression allows us greater resolution.

In the robotic phase, we make the first reconnaissance observations -- flybys of a planet or the first telescopic observations of extra solar planets. Our ability to see finer and finer detail and make more sophisticated analyses will increase.

Our exploration of this solar system illustrates the hierarchical structure.

We began with telescopic observations of the planets. This took place over centuries.

Next, we achieved spaceflight. Over the last three decades, we sent spacecraft to fly by the planets (e.g., Mariner II to Venus). We progressed and put spacecraft into orbit (e.g., Lunar Orbiter and the Mariner and Viking Orbiters) and landed them on the surface of other planets (e.g., Surveyor, Viking Lander) and now we will begin traversing planetary surfaces with intelligent robots (e.g., Pathfinder).

Now, in the coming decade, we're moving to more sophisticated vehicles to bring back samples from bodies in the solar system. Each advance in capability will increase our "resolution" (spatial, spectral, temporal, analytic).

A key element of planetary exploration is the use of humans in space. The participation of humans in the Apollo program (made possible by the corresponding great leap in technology of the Saturn program) let us pursue more complex

questions of lunar science. Robotic spacecraft alone couldn't have done the careful collection of a variety of lunar samples and complex experiments.

Humans provide a cognitive ability and versatility that robots will never have.

Example -- sent geologist Jack Schmidt on Apollo 17 to the Moon. His discovery that explosive volcanism occurred on the Moon (by finding orange glass) illustrates the serendipitous nature of science. You can't program every option into a computer.

But humans must only be used when there is a clear benefit. Is there the potential for high enough benefit to sustain the exploration of space by humans? The benefits can be scientific and economic.

For example, scientific benefits would include finding present or past forms of life, unraveling the climatic history of Mars which in turn could help us better understand the climate history of Earth.

Another example is to understand how planets are structured and how they evolved, and what that implies for the future evolution of the Earth.

The economic benefits might include finding resources to allow humans to live off the land (e.g., food, fuel, materials for habitats). We might find natural resources which are of commercial value (e.g., valuable metals or rare earths from an asteroid). We might find environmental conditions very different from Earth that will allow manufacture or production of high-value products.

And then maybe, just maybe, there are the recreational possibilities (e.g., the Hadley Rille Hilton).

As you can see, there are many issues. One of them, the search for life, is one of the more exciting and of interest to many of you here, who are life scientists, and to most Americans. It's intellectually and emotionally stimulating. So as a vehicle for

communication, let me just stick with this one subject.

We shouldn't get too enthusiastic. We may be alone.

On Earth we use humans for geologic field work because of their unique abilities in the field. If you're interested in a geologic problem in Australia -- like looking for evidence of ancient biogenic processes -- you don't use a Landsat picture. You go into the field.

There is a tangible payoff. The justification is clear -- the search can only be conducted on the ground with a trained scientist. If the problem could be done remotely, a human wouldn't have to go.

Defining the Life Zone

An important part of our quest is to define the life zone. By life zone, I don't just mean the range of distances from the Sun where we would typically think of liquid water as stable. I mean a broader more

encompassing definition -- the range or multidimensional space of temperature, pressure, composition and time in which conditions necessary for life could exist.

This covers regions where life does exist (i.e., the Earth), where it might have once existed, and where it could develop in the future.

With the robotic exploration of our solar system, we are beginning to define the limits of the life zone. Earth is clearly within the zone. Mars may be -- we are actively pursuing that question.

Venus may have been within the zone billions of years ago. Perhaps the interior of Europa is within that zone now. Maybe the surface of Titan or certain asteroids are.

Possibilities in Searching for Evidence of Life

Mars -- we believe that water flowed across the surface (evidence of the channels and canyons.) We think there are places

where standing bodies of water occurred, perhaps large lakes or even oceans.

We have observed large volcanoes on the surface of Mars. And there were probably hot springs and hydrothermal features. We believe organics may have been deposited on the surface by comets and asteroids, so the basic elements of life probably occurred at some time on Mars.

But did life evolve, and is it there now?

The next level of our search is to find those special niches and explore them. The general locations can probably be scouted out through robotic spacecraft.

But ultimately, the detailed sampling of layers of a sedimentary sequence, or picking apart a hydrothermal deposit will require the intellect, adaptability and manual dexterity of a human.

The search for extinct or extant extraterrestrial life leads us to investigate complex environments where the interplay of

geological, chemical, physical, and, perhaps, biological processes produce conditions that we can't predict. Some we can't even imagine.

Europa, one of Jupiter's satellites, may have a liquid water ocean up to 100 km deep beneath an ice crust about 10 km thick.

Europa is pulled and tugged by Jupiter and the other satellites. That causes its interior to heat up and may keep the water in a liquid state.

Its density suggests a composition similar to certain chondritic meteorites, which contain biologically important organics and all important biogenic elements.

The heating could lead to ocean-floor environments on Europa like those at Earth's oceanic hydrothermal vents, which support thriving biological communities and may have been the site of life's origin on the Earth.

Getting Ground Truth

Well, so what? What does investigating the life zone of this solar system do for us in our search for other solar systems?

It's our ground truth. We'll apply what we learn about the life zone in our solar system to our studies of worlds around other stars.

We've already found a number of Jupiter-sized bodies orbiting distant stars. We will certainly detect more and smaller bodies that could include moons of those Jupiter-size planets, maybe even moons like Europa and Titan.

Only through understanding the conditions under which life can or did develop here, can we guess whether these new bodies are hospitable to life forms that we observed in our own solar system. We have no references for life forms we have observed, so we'll have to really be open and scientifically imaginative.

One question is not whether there are planets around other stars, but whether there are Earth-like planets (little blue / green balls) orbiting other stars or other planets, different from Earth, capable of supporting life as we know it.

Perhaps we'll find a blue/purple Earth-sized planet. Maybe instead of chlorophyll, we'll find rhodopsin in the photosynthetic reaction, but life could still be the same.

The Four Phases of Exploration Have Thresholds

The four phases of exploration I mentioned previously have distinct thresholds.

Crossing from one phase to the next requires significant scientific, technological, and/or economic potential. There must be the promise of tangible returns. Why spend the money to take the next step if there is no benefit?

It's up to the research and commercial communities to define the levels of these thresholds. We must explore where the cost / benefit ratio passes the threshold for going on to the next phase.

In our quest, we need to gain additional information from remote sensing observation, exploration of the surface with rovers or balloons, and sample returns.

Then, when we have done our homework with robotic missions, we will consider the next step in our investigation. That will be the decision to send humans to wherever we think the most promising conditions exist to conduct detailed field work, sampling and experiments.

As we expand our human scientific investigations, we must learn how to "live off the land."

We may be able to use local resources even in the earliest human missions. We might not rely completely on those resources at first, but we could use them.

For example, water on Mars could be used for something as simple as replacing losses in an environmental system. It could be used for something as dramatic as making fuel for local flights across the surface or the return trip home.

There might be what seem to be diversions - like a series of missions to the Moon to demonstrate the viability of low-cost technologies. We must reduce exploration costs. Several years ago, the SEI activity estimated that it would cost \$500 billion to send humans to Mars. At that price, it's just not viable.

In order to cross the threshold into sustained human presence, we must be able to use the indigenous resources found in space and on the surfaces of planets. We must have economical means of transportation and communication. To cross this last threshold, we must be able to break the tether to the Earth. How much we achieve of this vision is dependent upon your future

contributions as scientists, educators and supporters of economic development.

How Can We Tell If There's Life on a Planet?

When looking out at other star systems, how could we tell if life exists? What are the potential atmospheric signatures for life?

For the last 2 billion years, Earth's atmosphere has had a distinctive ozone signature -- a sure indicator of oxygenic photosynthesis. Chemical disequilibria is maintained by biology. For example, methane or nitrous oxide in the presence of oxygen were seen by as signs of life on the Earth as the Galileo spacecraft flew by.

Organic sulfur rich compounds could be indicative of life in a reducing atmosphere, like our Earth during its first 1.5 billion years. Certain complex chemicals that are by-products or waste products of life or a predominance of an optically active pigment, like chlorophyll or rhodopsin, could be indicators.

The Technological Challenges

There are many elements to expanding human presence into space. In each area, we'll need one to two orders of magnitude improvement on performance and reliability from our previous efforts, not small steps of 10 or 20 percent, which has trapped us on this planet for the last 20 years. We must achieve revolution, not small, incremental change.

Some important areas include:

- Launch and cruise. This includes reaching Earth orbit, the transfer orbit to Mars or the Moon or wherever, and landing on the surface. Many of these elements must be reusable; all of them must be low cost. We can not throw away vehicles at each stage, after only one use.

Part of our activity will be outside the vehicles on the surfaces of other planets. This calls for unconventional space suits and personal spacecraft.

We will need advanced materials for the airframe and engines. Materials for the airframe will need high specific strength and stiffness. They must be resistant to thermal shock and have high reusability in a hostile environment.

The engines must be able to function up to a temperature of 3000°F. They don't necessarily have to be elastic. They must have high stiffness and strength-to-weight ratio.

Advanced structural concepts will be needed. For example, future systems will have integrated design of the tanks, aeroshell, and other elements to meet complex loading and environmental conditions. The elements must be reusable. Internal power systems will require advanced designs to make them robust, reusable, have high operating temperatures and able to function in the air. Non-chemical power systems will be needed to generate the required power beyond Earth orbit.

Vehicle health must be monitored and the uncertainties removed. We must quantify the risks and develop inflight options. There must be reliable, safe options for abort situations. And the all of the elements must be reusable and operable for a low cost. Turn-around time must be quick.

We need new concepts for surface power systems --

- On-orbit, light-weight solar concentrators for thermal-electric and photo voltaic systems,
- Dual-use electric propulsion systems able to power spacecraft and beam power to planetary surfaces,
- *In situ* mining for power production and storage will be required to support future exploration.
Geothermal power, particularly hot dry rock techniques, could also be a source for surface power.

- We must understand how human can live, adapt and work efficiently and effectively in space.

Radiation is a key concern. We must learn about its effects, how to predict its occurrence (e.g., solar flares) and how to protect the crew.

Advanced life-support systems for vehicles and EVA suits will be needed. Will they be partially closed loop or regenerative?

We'll also need advanced integrated spacecraft immune from cosmic rays and radiation. This shielding may utilize new carbonaceous and hydrogenated organics.

New medical techniques will be required to select and protect against cosmic radiation damage.

Microgravity and its influences on humans physiology must be considered. Long exposure to microgravity influences the heart, muscles, bones and immune and

nervous systems. We'll need counter measures. This also would enhance medical research on the Earth.

Totally new concepts for medical care must be developed for long space flights: nano-technology, chemical surgery, methods for selecting and inducing resistance to illness. Medical care will need to be supported by telemedical services that provide enhancement of diagnostic capabilities which update the crew on medical advances that have occurred since their departure.

We must learn to integrate robots and humans. Robots will be the human surrogate and assistant. They will see, hear, touch, smell, speak, think, learn and perform controlled mechanical operations.

Robots could be built to service the planetary vehicles in Earth orbit. They'd be propelled by electric propulsion and remain on orbit to service the vehicle or scientific instrument.

Telepresence and virtual reality will play a role in planetary exploration. Data can be returned to the Earth, and scientists will be able to investigate a site for great lengths of time in a virtual environment.

- We must develop tools that produce higher resolution (spatial, spectral, temporal) data while cutting development and life-cycle costs.

We'll need adaptive structures, surfaces, and electronics for the instrumentation of the future. Laser beams might replace rigid structures in interferometers. Floppy designs can be developed for zero g.

- A revolutionary change in design and analytic tools and simulation tools will be required for conceptual designs of space systems and scientific analysis.

We'll be using nonlinear, non-deterministic, and non-isotropic metals. We will have complex environmental inputs, stochastic processes and nondeterministic systems. We'll need to approach the problem

of design from the molecular level up, using physics-based design tools.

We must develop adaptive, learning, intelligent and self-generating software to deal with the chaos of the space environment. Adaptive systems must move from linear, deterministic engineering tools to expert systems, to ideas based on genetic principles.

Genetic algorithms will provide stable state changes in complex systems. Those processes and algorithms must be adapted into new tool sets.

We'll be operating in a geographically distributed work environment. There must be interconnectivity for interoperability with high bandwidth communications and a common multimedia tool.

We must reduce the complex information sets to understandable, narrow-band width displays. We will be totally immersed in interactive multi-sensory environments.

These new tools will provide products easily understandable by all. They will cut the cycle time. They'll cut development, manufacturing, testing and operations costs. And they will enable new technologies and systems.

New verification and validation concepts for these non-deterministic approaches will be needed.

Hardware must be developed for ground-based and space-based activities to support these design, operational and analytic tools. Where will the hardware and software boundary occur. Firmware? Dry or wet computers? Computers being microbiology based?

- Our understanding of the ethics of *in situ* space exploration must grow. How will we live and work on a planetary body and yet not contaminate it?

- Developing on-site infrastructure will be important. We must develop the capabilities necessary to live and work in

space and on the surfaces of other bodies. To achieve this we must learn more about ourselves as humans. That process will of itself lead to benefits to our culture and the manner in which we conceive ourselves.

NASA has a vision for a sustained human presence in the solar system.

- Twenty-five years from now, we want to have completed the robotic survey of the solar system. Our goal is to have identified planetary bodies that offer promise for the advancement of scientific understanding, commercial opportunities (e.g., Helium-3 or metal mining of asteroids) and recreational opportunities (e.g., the Hadley Rille Hilton or solar wind surfing on the Sea of Tranquillity).

- We want to have completed early low-cost rapid precursor demonstration missions for proof of concepts. These may be tested on the Moon or another body. We must demonstrate the safety, effectiveness and economic implementation of sustaining human presence in space and we want to have

begun the Initial Exploration with Humans and Robust Exploration with Humans.

- We want to have a data base on key bodies in our solar system to help design extrasolar exploration. We hopefully will have mapped stars, directly detected planets in the life zone, allowing for alternate life forms. We also will have analyzed those planets, and have obtained high resolution images of those planets which will allow us to answer fundamental questions of the origin of the universe.

Exploration of space will help define not only the conditions of life in the solar system and what happened. It will help us better understand the Earth and how it evolved.

Why does Venus -- with about the same mass and size as the Earth-- have a hot, crushing atmosphere? Why does Mars, which seems to have once been warmer and wetter, now exist as a cold desert? What is it that is so special about the Earth that life has survived for almost 4 billion years?

Our endeavor will be international. We won't be working alone.

There are challenges to all of this. We must be on the cutting edge with envelope expansion of technology capabilities, new systems, and scientific endeavors.

We must learn to use virtual and collaborative approaches for design, development, test, manufacturing, operations and scientific exploration. We must incorporate a new infrastructure into all homes with connections to computer networks.

We must rely on institutions of higher learning to establish a connectivity with us and lead the way to make this vision happen.

A key element of NASA's science program is working with other scientists in other disciplines.

Our aim as explorers and innovators should be to do science, to pursue

fundamental questions using all of the resources possible.

For understanding origins, this will involve ground- and space-based approaches. It will involve space scientists, physicists and biologists. And it will be the combined project of many agencies and many countries.

For example, high-energy physicists are using high-powered tools on Earth to learn about the nature of stars and the origin of the universe.

At the south pole, scientists from many universities, funded by the NSF, are placing long strings of photomultipliers at a depth of 2 km to detect neutrinos passing through the earth from supernovae, quasars, pulsars, and many other sources in the cosmos.

At the National Superconducting Cyclotron at Michigan State University, physicists from all over the world are using the ion accelerator to look at how elements are formed in stars and to study the

reactions that occurred in the early stages of the universe.

These are essential contributions that NASA can build on by using the unique capability of space to push toward higher resolution, *in situ* measurements, and to observe wavelengths impossible to access below the atmosphere.

NASA contributes to humankind's understanding of fundamental questions by stretching the boundaries of what humans can do on Earth.

Ending:

Decades from now, who knows what an unsuspecting Bell Atlantic employee may see if she knocks on a NASA Administrator's door.

Perhaps they'll sit in front of a screen and watch a picture slowly come into focus of a blue planet with clouds. Or see the first human emerge from a spacecraft on Mars and set a firm boot down in the red dust.

Perhaps they, and the rest of the world, will see something that changes history, changes what it means to be human. Perhaps they'll see something that suddenly, and forever, changes everything.